International Journal of Production Research, 2018
Vol. 56, No. 13, 4490–4520, https://doi.org/10.1080/00207543.2018.1431414

A literature review on performance measures of logistics management: an intellectual capital perspective

Ratapol Wudhikarn[a]*, Nopasit Chakpitak[b] and Gilles Neubert[c]

[a]*College of Arts, Media and Technology, Chiang Mai University, Chiang Mai, Thailand;* [b]*International College, Chiang Mai University, Chiang Mai, Thailand;* [c]*EMLYOM Business School, Campus Saint-Etienne, Saint-Etienne, France*

(*Received 15 April 2017; accepted 14 January 2018*)

Today, logistics management requires a comprehensive set of performance indicators that measure both tangible assets and intellectual capital (IC) of organisations. Nevertheless, most of the measures used in the past mainly related to the financial aspect, although some specific components of IC, such as process efficiency and effectiveness, have been considered. Logistics literature lacks a comprehensive consideration of the diverse IC measures, and it is unclear which area of IC requires more focus and development. Therefore, to explore and identify an opportunity for improvement, this study reviews the academic literature related to IC measures in logistics management. This literature review considers 111 academic articles published between 1994 and 2016. Following the six dimensions of the IC-Index, all indicators obtained from the literature are classified according to IC elements. The key contribution of this review is that it addresses the following gaps in the literature: the limited adoption of comprehensive IC methods in logistics studies; underdevelopment of specific indicators and measures used; failure to consider all human capital as well as renewal and development elements; and, finally, lack of academic research considering the influences among the different IC elements and logistics and financial performance.

Keywords: literature review; logistics; supply chain management; intellectual capital; performance measures; key performance indicators (KPIs)

Introduction

In the current business environment, logistics is a vital managerial issue for all businesses, not only for manufacturing, or goods-oriented, industries but also for service-oriented industries (Chiu 1995). Moreover, well executed logistics is empirically linked to enhanced organisational performance (Lambert and Burduroglo 2000; Lynch, Keller, and Ozment 2000; Davis-Sramek, Mentzer, and Stank 2008) and market share (Daugherty, Stank, and Ellinger 1998; Stank et al. 2003). Therefore, logistics is considered to be one of the critical strategic keys for business achievement and competitive advantages (Olavarrieta and Ellinger 1997). The basis of the concept of logistics is the intention to improve the efficiency and effectiveness of several operational activities in business, such as traffic and transportation, warehousing and storage, order processing, material handling and others. In the past, logistics was used interchangeably with several terms, including physical distribution and business logistics; however, logistics management (LM) is currently the most commonly used term among scholars (Lambert and Stock 1993; Chiu 1995). LM is identified as a vital concept for several industries (Chiu 1995). Because of its critical role and potential advantages, logistics management has been broadly implemented in many organisations worldwide. Due to this wide adoption, measurement of logistics performance, as well as application of a performance measurement system (PMS), has been regarded as extremely important (Griffis et al. 2007) to quantify the effectiveness and efficiency of logistics activities. Moreover, measurement of logistics performance can indicate opportunities for an organisation to improve its logistics, and thereby directly generate critical competitive advantages (Keebler and Plank 2009).

A PMS is defined as 'the set of metrics used to quantify both the efficiency and effectiveness of actions' (Neely, Gregory, and Platts 1995). For the past several decades, a PMS has been recognised as a basis for management (e.g. Bititici, Cavalieri, and Cieminski 2005; Bhagwat and Sharma 2007a). Therefore, in today's modern businesses, both commercial organisations and academic institutions have paid careful attention to PMSs. Nevertheless, a PMS needs to be properly constructed, taking into consideration several critical principles and especially focusing on non-financial measures (Maskell 1989) or intellectual capital (Basu 2001). Since all PMSs include a performance measure

*Corresponding author. Email: ratapol.w@cmu.ac.th

(Neely, Gregory, and Platts 1995) that can assist an organisation in identification of improvement opportunities and unachievable targets (Chan 2003), development of a good PMS helps foster organisational performance improvement (Gunasekaran and Kobu 2007), leading to the achievement of business goals. Furthermore, performance measures can also be applied with benchmarking techniques to compare competitive positions, which could be further utilised to obtain or regain market share from competitors (Wong and Wong 2008). Because of the several significant advantages of performance measurement in business management, this measurement element has been applied for management and operational purposes in domains such as manufacturing, business, society, education, tourism and medicine.

Like other business areas, management of logistics also requires proper performance measures and metrics to identify areas for improvement, and, thus, finally, to improve unsatisfactory performance of organisations. Therefore, in the past few decades, logistics performance measures have been broadly proposed and reviewed for both academic and commercial purposes. Performance measures have been explored and constructed in several different ways (Fugate, Mentzer, and Stank 2010). Nevertheless, the traditional performance measures for logistics management primarily depend on tangible or financial assets and some specific portions of intangible assets or intellectual capital (IC), including operational efficiency and effectiveness. Even though management of IC in logistics is considered to be an important issue with opportunities for improvement (Okada 2004), a comprehensive set of measures focusing on IC is still lacking, especially the measurement of human capital. However, in several empirical studies, good management of IC in logistics (e.g. Brah and Lim 2006; Yang, Marlow, and Lu 2009) and other industries (e.g. Ordóñez de Pablos 2005; Solitander and Tidström 2010) has been shown to provide a competitive advantage; this research demonstrates the positive effect of greater IC performance on profitability and revenue in the current and following years (e.g. Chen, Cheng, and Hwang 2005). Therefore, IC performance, which is defined as a proxy for efficiency or efficacy of human and structural capital, is identified as a crucial organisational component (El-Bannany 2011). IC management (ICM), a management approach concentrating on establishing IC measures and securing intellectual assets (Nickerson and Silverman 1997), has been suggested as a necessity for an organisation (Wiig 1997) to achieve efficient IC performance, obtain a competitive advantage, and realise organisational goals.

However, although there have been strong academic recommendations about the advantages of non-financial management (Lai et al. 2008), as well as bundling of tangible assets and ICM in logistics (Barney 1991; Teece, Pisano, and Shuen 1997; Karia and Wong 2013), past and current logistics studies focusing on measurement and management of IC are scarce. Moreover, most relevant research studies concentrate separately on each element of IC; that is, either human capital or structural capital. Studies on human capital management in logistics indicate that human resource management could bring advantages to organisations (Tromba 2005). These advantages would encompass the educational level, knowledge, and skills of the staff in the logistics service industry, especially at the management level, and this could also enhance the performance of the company (La Londe and Ginter 2002; Myers et al. 2004; Perng 2004; Karia and Razak 2007).

On the other hand, structural capital, another element of IC embedded in an organisation, is also mentioned as providing several advantages for an organisation's competitive capabilities. Several scholars (e.g. Gunasekaran and Ngai 2003; Gunasekaran, Patel, and McGaughey 2004; Panayides 2007) empirically found that relationships, which are a major part of structural capital, are a crucial fundamental aspect of organisational operations in logistics. Additionally, some empirical research studies identified relational capital as having a positive impact on the performance of logistics services (Panayides and So 2005; Karia and Wong 2013). The relational capital of logistics could be improved via primary and supporting activities, such as distribution, customer service, purchase order process and others. These value chain activities could influence the repurchase intentions of the customer, and, moreover, directly impact customer satisfaction as well as customer loyalty (Daugherty, Stank, and Ellinger 1998). Finally, these could also affect the increment of organisational profits (Sharma, Grewal, and Levy 1995) and sales growth (Stank et al. 2003), as well as competitive strength (Mentzer and Williams 2001). In the same way, organisational capital, another sub-element of structural capital, was also studied and noted for its critical competitive advantage for logistics companies (Karia and Razak 2007; Panayides 2007). This capital is also specified as an essential component for logistics service providers to develop and execute strategic as well as operational functions (Karia and Wong 2013). Furthermore, several elements of organisational capital could lead to organisational advantages; for example, information technology (IT) could obtain and collect valuable knowledge about the human capital within the organisation (Hansen, Nohria, and Tierney 1999; Sauvage 2003), while patents could strengthen the competitive advantages of logistics (Wu and Lin 2005; Wu 2006).

As previously mentioned, management of IC in logistics could improve organisational performance in both the financial and non-financial dimensions. With this point clearly proven, considering and identifying performance measures of IC are suggested as an inevitable task in the logistics domain. There are some limited attempts at state-of-the art review studies (Gunasekaran and Kobu 2007; Akyuz and Erkan 2010), aiming to reveal the status of and gaps in performance measurement of IC in logistics and more extensively in the supply chain management (SCM) environment.

Nevertheless, in terms of the adoption of an IC classification, these reviews provided only a very rough suggestion of the need for more attention and holistic development of IC measurement and management. They still did not provide clear and detailed suggestions at the level of sub-segments of IC. Therefore, this rough recommendation is still inconsistent with the current status of logistics management, which requires a focus on a comprehensive performance measurement model or a wide range of IC measures that cover all the details of IC elements and measures (Wu and Chou 2007; Bhagwat and Sharma 2009). There is still no existing study that specifically reviews a comprehensive set of performance measures of IC in logistics management.

Considering the advantages of utilising a comprehensive range of IC measures in logistics that cover all elements, the previously provided suggestions about IC performance measurement have not fully compiled the details of specific gaps in performance measurement or the opportunities for improvement. A systematic approach to reviewing past literature is needed to comprehensively draw attention to the status of IC performance measures in logistics, and the areas where improvement is required. Such a literature review can supportively identify content relating to the subject (Meredith 1993), and can be further applied to contribute to the development of theory (Harland et al. 2006). Therefore, this study aims to describe the current situation of IC performance measurement in logistics, and to identify future research opportunities, such as ways to improve performance measurement of IC in logistics management and performance measures of IC related elements within logistics management that need further study and enrichment.

The remainder of the paper is organised as follows. The next section briefly describes the theoretical concepts and classifications of IC. The review methodology is identified in the third section. The fourth section presents the results and findings of the reviewed literature and the fifth section provides the analysis of the results obtained. Finally, the last section provides the overall conclusions of this study.

Intellectual capital

The drastic increment of data and information in the current era, known as the knowledge economy, transforms organisational attention and operations from the traditional approach to a more complicated and comprehensive approach (Al-Ali 2003). Therefore, in the past few decades, business management has changed from the classic approach, which principally concentrates on finance, to a more sophisticated approach that expansively considers non-financial resources, also known as intellectual capital (IC). IC or intangible assets are simply defined as 'those that have no physical existence but are still of value to the company' (Edvinsson and Malone 1997). IC includes ideas, designs, computer software, mobile applications, data processes, employee knowledge, innovations and intellectual property, which excludes all tangible assets, such as cash, inventory, equipment, buildings and land (Edvinsson and Sullivan 1996). The topic of IC has been widely considered and dealt with by both scholars and practitioners (Petty and Guthrie 2000). From the commercial perspective, IC is specifically identified as the territory of the chief knowledge officer (Bontis 2001). Several studies have indicated that IC is a critical organisational asset that cannot be found in a balance sheet or any other traditional financial report (e.g. Stewart 1997; Ordóñez de Pablos 2005). Moreover, IC has been empirically identified as a key competitive advantage of organisations (Hsu and Fang 2008; Kale 2009; Solitander and Tidström 2010).

Initially, however, intellectual capital was identified as an indeterminate asset because it was difficult to measure and manage (Koçoğlu, Manoğlu, and İnce 2009). Since a categorisation would provide clearer details than just a description, several studies have attempted to suggest classification of IC as a part of a balanced scorecard (Kaplan and Norton 1992), value platform (Petrash 1996), or Skandia value scheme (Edvinsson and Malone 1997); an intangible asset monitor (Sveiby 1997); thinking and non-thinking assets (Roos et al. 1997), or a component of the IC measurement model (Chen, Zhu, and Xie 2004). Most of the models attempted to categorise IC into three or four large dimensions that are quite extensive, whereas the thinking and non-thinking assets, also known as the IC-Index (Roos et al. 1997), considers a more comprehensively detailed performance metric. Thinking assets refers to the employees who create value for the firm using their capital, whereas non-thinking assets simply represent the infrastructure of the organisation (Raghavan 2011). The IC-Index classifies IC elements into these two major parts, and each main element is broken down into three subparts. Human capital consists of competence, attitude and intellectual agility, while structural capital is comprised of relationships, organisation and renewal and development.

The first major element of IC, human capital, is succinctly defined as the stock of personal knowledge in a firm (Bontis, Crossan, and Hulland 2002); however, human capital does not actually involve just knowledge or competence, but also attitude and intellectual agility. Among these components, competence is described as an asset that depends on the knowledge, skills and know-how of the organisational staff, whereas attitude is a soft element that represents the willingness to utilise the competence and motivation of employees to achieve the final objectives of the organisation. Intellectual agility is a company's capability to transfer and improve existing knowledge through adaptation and innovation. Human capital is considered the most significant IC element, since it can generate value and creativity in

companies (Bozbura, Beskese, and Kahraman 2007), as well as enhance organisational performance (Hunt 2000). Moreover, an increment in employees' competence directly influences a positive financial outcome (Becker, Huselid, and Ulrich 2001). Nevertheless, this capital can easily vanish through resignation, retirement, or unavailability of employees. Therefore, the company should monitor and manage this capital closely and earnestly.

On the other hand, structural capital, the other major IC element, is different from human capital. Structural capital is an intangible asset and infrastructure that supports employees in their work (Luthy 1998). Following the IC-Index concept, structural capital reflects the elements of the internal and external value of the organisation through organisation and relationships, respectively, and the element of renewal and development represents the future value of the firm. Organisation or organisational capital is defined as the capital used to blend human capital and tangible assets into systems for delivering products or services (Evenson and Westphal 1995). This capital is also conversely considered as a tool with high-potential for providing standard guidelines and basis for all employees (Brusoni, Prencipe, and Pavitt 2001). Organisation primarily consists of infrastructure, operational processes, culture and manner of management. The second element, typically called relational capital, is defined as the value of the business relationships between a company and external parties, including customers, suppliers, shareholders, other stakeholders and alliance partners (Roos et al. 1997; Roos and Roos 1998). The last component of structural capital is renewal and development capital. This intangible asset represents all things in the organisation that hold future value.

As indicated previously, the IC-Index provides a clear, detailed classification, including the major and sub-elements of intellectual capital. Moreover, a broad consideration of IC elements could better provide a comprehensive evaluation and details of intellectual capital than other IC methods. Therefore, to properly scope and classify IC dimensions in this study, the IC-Index method is adopted.

Research methodology

This section provides a method of reviewing the literature related to performance measures of IC in logistics management by referring to the generic processes found in several literature reviews (e.g. Mayring 2008; Agrawal, Singh, and Murtaza 2015). There are three major steps in this well-organised process, including material collection, descriptive analysis and classification; details of each step are presented in the following section. Moreover, the final process of analysis is also included to identify the analysis approach used for the articles considered and the IC measures obtained.

First, this study is conducted by focusing on data and material collection. To obtain articles relevant to the study's focus on performance measures of IC in logistics management, keywords are identified by considering a direct word, related term, synonym, or abbreviation related to focus areas as follows:

- Logistics management keywords: logistics; supply chain.
- Intellectual capital keywords: intellectual capital; IC; intangible assets.
- Performance measure: performance measure; key performance indicator; KPI.

To widely detect appropriate research, the term 'logistics', which is a component of both logistics and LM, is specified as a search term for logistics management. Additionally, 'supply chain', a broader term encompassing logistics, is included as a keyword to find studies conducted using a broader scope that might also include a study of logistics management. 'Intellectual capital' and 'IC', a direct word and its acronym, respectively, are selected as search terms for intellectual capital, as well as the most widely used synonym for IC, 'intangible assets'. Finally, for the scope of performance measures, the direct word 'performance measure' was specified, along with the most related word and its abbreviation, 'key performance indicator' and 'KPI', respectively. KPI is also indicated as a measurement attribute that could be used interchangeably with measures (e.g. Julnes 2007; Choong 2013), and both 'key performance indicator' and 'KPI' could provide information regarding tangible or intangible elements (Choong 2013).

The above-mentioned keywords are all combined, and 18 combinations of three terms from each subject are created and then used in the article title and keyword search. The development of IC began in the early 1990s (see Marr and Chatzkel 2004; Choong 2008), so the search is conducted from 1990 to March, 2016. All academic databases that contain high quality journals in logistics and supply chains according to survey findings (Kovács, Spens, and Vellenga 2008) that could be accessed by the authors are searched to discover all possible related journal articles; the databases included ScienceDirect (www.sciencedirect.com), Emerald (www.emeraldinsight.com), Springer (www.springer.com), and Taylor and Francis (www.tandfonline.com). As previously mentioned, the identified keywords, search combinations, and selected time range, as well as accessible academic databases, are then applied to search for and acquire all articles possibly related to the purpose of this study. At first, all obtained papers are screened for relevance by examining the titles to identify whether the scope is related to management or measurement of performance in logistics or supply chains. After that, to initially screen the related articles given the limited resources and time, only the abstracts of the

selected articles are screened for any mention of performance measurement or performance measures in logistics or supply chains. Thereafter, to select only directly related articles, the screened articles are reviewed by searching the whole document for performance measures of IC in logistics management.

After following this process, all related articles were collected and the descriptive analysis was performed. In this process, the previously obtained articles were classified by the frequency of journal title and year of publication to demonstrate the level of attention on the focused topic in terms of publishers and time period, respectively. The classification is carried out to examine the concentration of IC in logistics studies. In this process, each article is thoroughly examined in its entirety for performance measures. Nevertheless, despite our screening approach, the selected articles still included studies involving the overall scope of logistics, which is supply chain management. Therefore, to identify only logistics and IC-related measures from these papers, the scope and activities of logistics as identified by Lambert, a guru of logistics and SCM, and his colleagues (Lambert, Stock, and Elram 1998), are applied. Logistics processes include customer service, demand forecasting, distribution communication, inventory control, material handling, order processing, parts and service support, plant and warehouse site selection, procurement, packaging, returned goods handling, salvage and scrap disposal, traffic and transportation and warehousing and storage. However, the size of the collection of selected articles still could have created a significant number of measures; hence, to reduce the measures to a manageable number, some of the them were consolidated or removed in the following manner:

- Analogous and conflicting measures were combined, or
- The too narrow or specific indicators were amalgamated with more generic measures,

Additional measures are also excluded for one of the following reasons:

- The measures were not a part of logistics, as identified by Lambert and colleagues (1998), or
- The indicators represent similar practices, based on the suggestions of Gunasekaran and Kobu (2007), as well as Kucukaltan, Irani, and Aktas (2016).

The identified and screened indicators from each paper are classified as a financial element or IC-related element following the IC-Index approach. Therefore, performance measures and their focused dimensions (either financial or IC dimensions) were indicated for each article. From these results, the articles were then classified by separating them into two major perspectives. The first perspective attempts to demonstrate the concentration of the article from both financial and IC perspectives. Therefore, the articles are classified into three major categories: financial capital, intellectual capital and financial and intellectual capital. Moreover, to comprehensively explore the major perspectives of IC, these three groups are further broken down into six sub-categories. Two of the categories focus only on one specific type of capital: (1) human capital and (2) structural capital. The remaining categories consider more than one type of capital: (3) human and structural capital; (4) financial and human capital; (5) financial and structural capital; and (6) financial, human and structural capital. From another perspective, to specifically concentrate on IC-applied measures, all reviewed articles were categorised by six sub-elements of IC following the IC-Index approach, including competence, attitude, intellectual agility, relationships, organisation and renewal and development.

The descriptive analysis and classification process demonstrates the distribution of IC-related articles in logistics following the publisher name, time range and IC dimensions; however, this could represent only the level of IC-focused articles. Therefore, in the analysis step, to realise more detail on the level of performance measures, all collected measures from articles obtained were examined to identity what they were intended to measure, and then classified into IC-related elements following the IC-Index by considering the counterparts of scope and objective. This process aims to analyse and demonstrate the level and gaps of application of IC-related measures in logistics. Thereafter, the information obtained in the results and analysis sections are applied and examined to discuss and illustrate the possibilities for improvement, as well as to identify future research opportunities.

Results

Using the keywords and search combinations, and the focused time range identified in the previous section, 1711 academic articles were initially obtained. These studies were further filtered by considering the articles' titles. In this step, 227 articles were chosen, and the abstracts of these articles were screened for relevance. From this second filtration, 112 academic papers were chosen from several journals, and each was reviewed by searching the whole document for performance measures of IC in logistics management. One article that did not meet the focused scope of this review was further excluded. Therefore, this process results in 111 articles being extracted for performance indicators of IC in logistics management. This final number of reviewed articles seem to be adequate compared to other literature reviews regarding performance measurement (e.g. Gunasekaran and Kobu 2007; Akyuz and Erkan 2010).

Descriptive analysis

This section provides a descriptive analysis of the papers that were reviewed. The selected papers were categorised by the frequency of the journal publisher and the publication period in Table 1 and Figure 1, respectively.

As depicted in Table 1, there were several articles from diverse publishers relating to the topics considered. Most of the relevant articles were published in well-known and high-quality journals, such as the International Journal of Production Research, Benchmarking: An International Journal, Supply Chain Management: An International Journal, Production, Planning & Control and the International Journal of Productivity and Performance Management. The scope of the selected journals primarily relates to operations research, industrial engineering, performance measurement, industrial and expert systems, business management, transportation, logistics, supply chain management and decision science.

The publication dates of the selected articles, ranging from 1994 to March 2016, are illustrated in Figure 1. Although articles considering performance measurement in logistics have been published for a long time, the topic specifically examined in this study has developed more in recent years; moreover, the number of studies has also increased. This reveals that the strong focus on this topic has been quite recent.

Classification

Using the approach and conditions identified in the methodology section, all 111 related articles were thoroughly examined for performance measures, and the obtained indicators were then sorted out, consolidated, and removed. After that, the resulting measures collected were classified into IC-related elements following the IC-Index concept. Therefore, using this process, each paper could be classified into IC dimensions following their categorised measures. The articles were classified by separating them into two levels. The first level attempts to demonstrate the concentration on both financial and IC measures, and this classification is shown in Table 2.

Based on these categories, most of the articles reviewed were found to consider more than one specific capital of performance measurement. The measure of financial and structural capital is the most studied category (60.36%), while all categories related to human capital in logistics are still less examined, and require further exploration.

From another perspective, the reviewed articles were categorised by IC sub-elements following the IC-Index approach. This classification, presented in Table 3, demonstrates several crucial points that were not clearly identified in

Table 1. Number of selected articles sorted by publishers.

Publisher of articles	Numbers of articles per journal
International Journal of Production Research, *Benchmarking: An International Journal*	11
Supply Chain Management: An International Journal, *Production Planning & Control*	10
International Journal of Logistics Research and Applications	6
International Journal of Productivity and Performance Management	5
Transportation Research Part E, *International Journal of Production Economics*, *Industrial Management & Data Systems*, *International Journal of Physical Distribution & Logistics Management*, *Journal of Statistics and Management Systems*	3
Journal of Cleaner Production, *Procedia – Social and Behavioural Sciences*, *Computers and Industrial Engineering*, *International Journal of Operations & Production Management*, *The International Journal of Logistics Management*	2
Transportation Research Procedia, *Procedia Engineering*, *Industrial Marketing Management*, *Expert Systems with Applications*, *Decision Support Systems*, *Applied Mathematical Modelling*, *Omega*, *Procedia Materials Science*, *Asia Pacific Journal of Marketing and Logistics*, *Business Process Management Journal*, *Facilities*, *International Journal of Business and Information*, *Journal of Enterprise Information Management*, *Journal of Manufacturing Technology Management*, *Management Decision*, *Measuring Business Excellence*, *Strategic Outsourcing: An International Journal*, *Cogent Business & Management*, *Engineering Management Journal*, *Enterprise Information Systems*, *International Journal of Systems Science*, *Journal of Information and Optimization Sciences*, *The International Review of Retail*, *Distribution and Consumer Research*, *The Service Industries Journal*, *Total Quality Management & Business Excellence*, *Transport Reviews*, *Global Business Perspectives*, *Global Journal of Flexible Systems Management*, *Journal of Industrial Engineering International*, *Journal of Intelligent Manufacturing*, *Logistics Research*, *Review of Managerial Science*, *The International Journal of Advanced Manufacturing Technology*	1

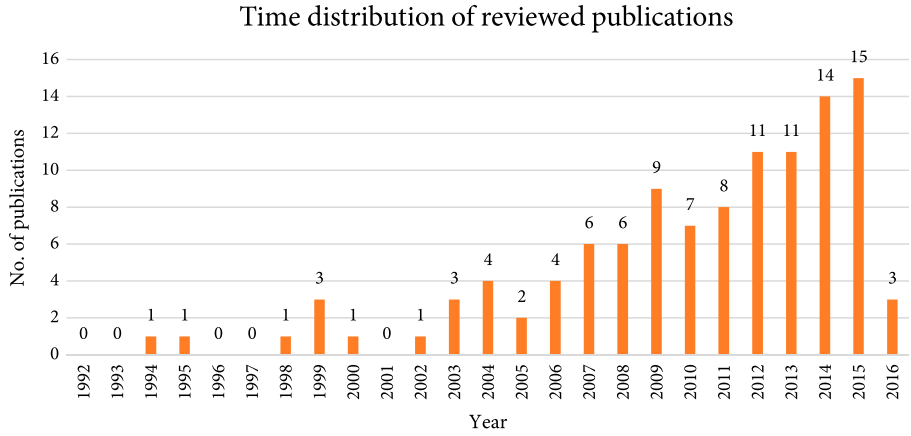

Figure 1. Distribution of the publication dates of the reviewed articles.

Table 2. Classification of reviewed articles considering financial and non-financial perspectives.

Classification of articles	Percentage
Financial capital	–
Intellectual capital	*16.22*
Human capital	–
Structural capital	9.91
Human and structural capital	6.31
Financial and intellectual capital	*83.78*
Financial and human capital	–
Financial and structural capital	60.36
Financial, human, and structural capital	23.42

previous studies. Notably, none of the studies simultaneously considered all six components of IC, and there is no research specifically focusing on the logistics-related measures of competence, attitude, intellectual agility and renewal and development. Most of the logistics studies were found to consider just relationships and organisation measures (36.04%) or only organisation measures (21.62%), and almost all the articles (94.58%) referred to the measurement of organisational capital.

Analysis

In this section, the reviewed literature was further analysed to provide more detail on the findings related to performance measures of intellectual capital in logistics. All filtered measures from 111 articles were considered based on their purposes, and then each indicator was categorised into the IC-related element using the six categories of the IC-Index. Using the results of this process, we aim to analyse the level of attention and application of IC measures, and to highlight the gaps in IC measurement in logistics management. In the next subsections, logistics measures classified by identified approach are presented and analysed.

Human capital

Human capital is academically described as the total depository of personal knowledge and capabilities in an organisation (Bontis, Crossan, and Hulland 2002). The human perspective has been empirically identified as a crucial factor for attaining several logistics-related goals (Van Hoek, Chatham, and Wilding 2002). Moreover, effective management of human capital is conducive to organisational achievement (Tromba 2005). Nevertheless, performance measurements from the human capital perspective were rarely studied, and were also rarely considered in logistics. It was evident from the reviewed articles that there had been no study specifically focusing only on the human capital of logisticians. All

Table 3. Classification of articles considering IC elements.

Classification of articles	Percentage
One element of IC	*22.52*
Relationships	0.90
Organisation	21.62
Two elements of IC	*38.74*
Relationships and organisation	36.04
Relationships and renewal and development	0.90
Organisation and renewal and development	1.80
Three elements of IC	*20.72*
Attitude, relationships, and organisation	1.80
Competence, intellectual agility, and organisation	0.90
Competence, relationship, and organisation	8.11
Competence, organisation and renewal and development	0.90
Intellectual agility, organisation and renewal and development	9.01
Four elements of IC	*12.61*
Attitude, competence, organisation and renewal and development	0.90
Attitude, competence, relationships, and organisation	3.60
Attitude, intellectual agility, relationships and renewal and development	0.90
Attitude, relationships, organisation and renewal and development	5.41
Competence, relationship, organisation and renewal and development	0.90
Intellectual agility, relationship, organisation and renewal and development	0.90
Five elements of IC	*5.41*
Attitude, competence, relationship, organisation and renewal and development	3.61
Competence, intellectual agility, relationship, organisation and renewal and development	1.80
All (six) elements of IC	–

the papers that considered human capital were found to be combined with structural and/or financial capital simultaneously. Moreover, these articles were all related to the application of the balanced scorecard, or BSC (Chia, Goh, and Hum 2009; Bansia, Varkey, and Agrawal 2014; Golrizgashti 2014; Shafiee, Lotfi, and Saleh 2014; Shaik and Abdul-Kader 2014; Okongwu, Brulhart, and Moncef 2015); development of comprehensive, or improved performance measurement frameworks (Holmberg 2000; Morgan 2004; Hervani, Helms, and Sarkis 2005; Seth, Deshmukh, and Vrat 2006; Wu and Chou 2007; Kunadhamraks and Hanaoka 2008; Sha and Chen 2008; Sambasivan, Nandan, and Mohamed 2009; Thakkar, Kanda, and Deshmukh 2009; Shepherd and Günter 2011; Huang et al. 2012; Shaik and Abdul-Kader 2012; Dey and Cheffi 2013; Shaik and Abdul-Kader 2013; Turi, Goncalves, and Mocan 2014; Alkhatib et al. 2015; Anand and Grover 2015; Guarnieri et al. 2015; Jakhar 2015; Moreira and Tjahjono 2016); literature review (Elrod, Murray, and Bande 2013; Aguezzoul 2014); IC consideration (Caplice and Sheffi 1995; Su, Fang, and Young 2013); benchmarking (Mbaga et al. 2011); impact of resources on performance (Karia and Wong 2013); content analysis (Piecyk and Björklund 2015); and identification of logistics capabilities (Huang and Huang 2012).

As demonstrated, consideration of human capital was mostly found in BSC applications and improvement of logistics performance evaluation frameworks. This concentration occurred because the BSC technique widely focused on IC through the learning and growth dimension, which is directly related to human capital, while other improved frameworks also aimed to develop more extensive performance measurements by including the value of employees. Throughout the reviewing and classifying process, all human-related measures were analysed, and it was concluded that they were sub-perspectives, as presented in the next sections.

Competence

Since the critical success of logistics depends on sufficient employee knowledge and ability to execute processes by responding to customer satisfaction (Wu and Chou 2007), competence is the element that deserves the most concentration, according to viewpoints on human capital in logistics-related articles. Around 64% of human-focused studies measured or examined the knowledge, skills and competence of employees, and the results of the analysis of measures are presented as follows:

- Rate of trained employees (found in twelve articles including Hervani, Helms, and Sarkis 2005; Kunadhamraks and Hanaoka 2008; Sambasivan, Nandan, and Mohamed 2009; Thakkar, Kanda, and Deshmukh 2009; Mbaga et al. 2011; Huang et al. 2012; Su, Fang, and Young 2013; Turi, Goncalves, and Mocan 2014; Alkhatib et al. 2015; Anand and Grover 2015; Jakhar 2015; Piecyk and Björklund 2015),
- Skills and competence level of employees (found in eight articles including Holmberg 2000; Seth, Deshmukh, and Vrat 2006; Sambasivan, Nandan, and Mohamed 2009; Shepherd and Günter 2011; Huang et al. 2012; Shaik and Abdul-Kader 2012; Karia and Wong 2013; Aguezzoul 2014),
- Workforce flexibility (found in five articles including Chan 2003; Thakkar, Kanda, and Deshmukh 2009; Huang et al. 2012; Shaik and Abdul-Kader 2012; Elrod, Murray, and Bande 2013),
- Personnel efficiency (found in three articles including Sambasivan, Nandan, and Mohamed 2009; Huang et al. 2012; Golrizgashti 2014),
- Number and type of certificates/training programmes (found in three articles including Huang et al. 2012; Golrizgashti 2014; Alkhatib et al. 2015),
- Years of experience (found in three articles including Huang et al. 2012; Su, Fang, and Young 2013; Alkhatib et al. 2015),
- Investment in employee training (found in two articles including Chia, Goh, and Hum 2009; Shafiee, Lotfi, and Saleh 2014),
- Number of employees (found in two articles including Caplice and Sheffi 1995; Wu and Chou 2007),
- Rate of graduated employees (found in one article including Su, Fang, and Young 2013).

Since the most frequently referred to measure in the reviewed papers was the competence measure of logistics, it is not surprising that the two most used measures were rate of trained employees and knowledge and skills of employees, generic measures that conform to past studies in either logistics (Wu and Chou 2007) or other domains (e.g. Chen, Zhu, and Xie 2004). There are also other indicators that are common to the generic metrics of IC identified by Roos et al. (1997) and the CMA (1999); these are workforce flexibility, years of experience, number of employees, rate of graduate employees and investment in employee training. On the other hand, there is one measure in logistics studies, personnel efficiency that has not been previously mentioned by other generic IC studies. Moreover, from the classic IC book (Roos et al. 1997), there is a suggested measure, 'information technology (IT) literacy of employees', that was not included in any of the reviewed articles, although it has been suggested as a generic indicator of competence measurement, and IT is empirically identified as a critical part of logistics, (Sauvage 2003). Therefore, this gap can be considered as an opportunity for improvement through a competence measurement in logistics.

Attitude

Attitude of employees is identified as a soft part of human capital. This minor element represents both willingness towards the organisation and satisfaction from the workplace (Chen, Zhu, and Xie 2004). It is a vital impeller supporting the usability of competence of employees. During the review process, it was found that there were a few studies, as in the competence-focused papers, using attitude for performance measurement. Around 18% of all reviewed articles and 61% of the studies related to human capital mentioned the measure of employees' attitudes. There still is a large gap regarding consideration of attitude in logistics performance measurement, as in the case of competence. The results of the analysis of measurement of attitude in logistics are presented as follows:

- Employee satisfaction (found in eight articles including Sha and Chen 2008; Chia, Goh, and Hum 2009; Sambasivan, Nandan, and Mohamed 2009; Shaik and Abdul-Kader 2012; Shaik and Abdul-Kader 2013; Shaik and Abdul-Kader 2014; Shafiee, Lotfi, and Saleh 2014; Okongwu, Brulhart, and Moncef 2015),
- Employee turnover per year (found in seven articles including Morgan 2004; Wu and Chou 2007; Chia, Goh, and Hum 2009; Sambasivan, Nandan, and Mohamed 2009; Huang et al. 2012; Golrizgashti 2014; Shafiee, Lotfi, and Saleh 2014),
- Willingness and positive attitude (found in three articles including Seth, Deshmukh, and Vrat 2006; Huang et al. 2012; Guarnieri et al. 2015),
- Employee participation and cooperation rate (found in three articles including Sha and Chen 2008; Huang et al. 2012; Alkhatib et al. 2015),
- Motivation plan (found in two articles including Dey and Cheffi 2013; Golrizgashti 2014),
- Employee truancy rate (found in one article including Caplice and Sheffi 1995),
- Employees with incentives (found in one article including Hervani, Helms, and Sarkis 2005),

- Rights of employees (found in one article including Kunadhamraks and Hanaoka 2008),
- Work load of employees (found in one article including Reiner and Hofmann 2006).

These results demonstrate the great emphasis on employee satisfaction and employee turnover identified in several focused articles, and the amount of attention placed on the contribution of the organisation to the employee. Moreover, the top two indicators are also related to the typical employee attitude measurement suggested by well-known IC studies (e.g. Bontis 1997; Edvinsson and Malone 1997). In contrast, other attitude measures were rarely applied in logistics studies, and, furthermore, from all the reviewed indices, there was only one measure specifically focusing on the impact of employees, which concentrated on employee participation and cooperation. Therefore, from this result, measurement of employee attitude could be taken further in the logistics management domain.

Intellectual agility

The last sub-element of human capital, intellectual agility, is that which enables employees to improve existing practices and innovate solutions, products, or processes. It is remarkable that few studies of logistics measurement have considered the measure of intellectual agility. There were only five articles, or around 4% of all reviewed articles, that applied this human-related measure, and those few related indicators are as follows:

- Number of implemented suggestions (found in three articles including Chia, Goh, and Hum 2009; Shafiee, Lotfi, and Saleh 2014; Turi, Goncalves, and Mocan 2014),
- Employee rewards for innovative ideas (found in one article, Huang and Huang 2012).

These results show that only two key measures were used for measuring intellectual agility in logistics, and the most employed measure is the number of implemented suggestions per employee. These two indicators are generally found as generic measures of intellectual agility in IC studies. Instead of these limited measures, there are several typical metrics that could be better used for performance measurement of this sub-dimension, such as new solutions, processes, processes suggested, income from suggested ideas and others.

Structural capital

Structural capital is simply defined as everything in a firm that supports human capital in their operation and job (Luthy 1998). Components of structural capital, especially relational and organisational capital, have been empirically identified in several studies either as a driver of positive impact or as a competitive advantage of logistics (e.g. Karia and Razak 2007; Panayides 2007; Karia and Wong 2013). Measurement of structural capital, including internal processes and the customer perspective, is broadly applied and acts as a critical part of the logistics and supply chain environments discussed in the review study of Gunasekaran and Kobu (2007). Nowadays, measurement of structural capital is perceived as another crucial part of measuring organisational performance (e.g. Karami and Vafaei 2011; Gogan, Duran, and Draghici 2015). This conforms to the results obtained from the review process, demonstrating the high proportion of studies applying structural measures, as shown in Table 2. Around 84% of all articles focus on structural capital measures along with other measures.

As presented in Table 2, structural capital is the only measurement considered by all the articles. It was applied with financial capital or human capital measurement, or both. Moreover, it is also the only capital that is exclusively studied in some logistics articles. From this information, it can be inferred that structural capital measurement is very important and critical in logistics, so it is now an inevitable managerial consideration. Nevertheless, although there is the greatest focus on this IC type among the sub-elements, there are several opportunities for further examination, and these will be explained in the coming sections.

Relationships

Relationships or relational capital represent the value of organisational relationships with all associated partners. This capital works as both a connector and an accelerator of IC operations; moreover, it is identified as the convertor that transforms IC into market value and organisational performance (Chen, Zhu, and Xie 2004). Relational capital generally represents the weakest area of logistics, and it is directly influenced by the performance of organisational capital (Wu and Chou 2007). On the other hand, good performance in maintaining relationships could lead to achievement of several organisational goals, such as greater market share (Stank et al. 2003) and better competitive capability (Mentzer and Williams 2001). Moreover, the ultimate objective of human capital in logistics, as well as other kinds of structural capi-

tal, is to attain customer satisfaction, one of the measures of relational capital (Wu and Chou 2007). Therefore, unsurprisingly, the review shows that measurement of relational capital has been considered and applied with other IC elements in almost all studies shown in Table 2. In addition, 74% of all reviewed articles used relational capital measures for assessing logistics performance; all the applied indicators are shown in Table 4.

Table 4 illustrates the relational measures applied in the reviewed logistics articles. As shown, the first indicator used is customer service level. This measure is frequently used in relationship-related articles and all studies, at 43% and 32%, respectively, possibly because it is used as a leading indicator for organisational profits and competitive strength, as identified in previous studies (e.g. Mentzer and Williams 2001; Stank et al. 2003). Moreover, from Table 4, it can be observed that most applied indicators focus on customers, followed by suppliers, whereas measurements related to other collaborators, especially shareholders, stakeholders and alliances, are rarely employed in logistics articles. Nevertheless, there are still some measures that concentrate on other indirect partners, and these measures include alliance performance and social responsibility, each considered by one article. Therefore, improvement of relationship-related measures specifically focusing on the omitted partners requires more attention.

Renewal and development

Today, capability of renewal and development has been broadly accepted as an important element of intellectual capital, as well as a critical competitive advantage in several domains. In logistics, renewal and development, or innovation, are especially identified as key means of differentiation among competitors (Sauvage 2003); this structural sub-element could also improve logistics service abilities (Chapman, Soosay, and Kandampully 2003). Nevertheless, performance measurement of renewal and development, even in a generic IC form, is underdeveloped for properly capturing this capability (Pöyhönen 2004), and it has been greatly neglected, especially regarding the operational perspective (Junell and Ståhle 2011). As in the logistics domain, it is evident from the obtained results that concentration on measurement of renewal and development is rare. Only around 27% of the selected articles were found to use or mention this kind of IC measure; this is also the smallest proportion among all structural capital elements. The results of the measurement of renewal and development are given in Table 5.

Table 5 demonstrates that indicators representing performance of the renewal and development dimension mostly depend on innovation, new products, new services, or new technology, and change or development. Among these indices, the most employed measure is the organisational ability for innovation; there are three other indicators that are also frequently used in logistics studies, including new product/service launching time or mass production time, usage of innovation, and flexibility of new products/services. Nevertheless, as previously mentioned, the proportion of studies focusing on renewal and development capability is limited; this IC element could be included more in the logistics framework or evaluation so that its competitive advantages are suggested and conveyed to organisations.

Organisation

Organisation or organisational capital is a type of IC typically concentrated in the management of organisations; it has been greatly focused on by both academic and commercial studies (Webster and Jensen 2006). This intangible element is identified as the capital applied to merge human capital and financial capital into organisational systems to deliver a company's products or services. Organisational capital is a crucial tool that makes the environment conducive for successful cooperation between various and diverse groups and communities (Aribi and Dupouët 2015). Therefore, the unique characteristic of organisational capital is that it is broadly applied as a tool for supportively aligning the different types of knowledge and capabilities of human beings (Tushman and Rosenkopf 1992). In the logistics domain, management of organisational capital has been accepted as a key competitive advantage, driving logistics companies to be leaders in global competition (Sauvage 2003). Moreover, efficient use of organisational capital in logistics has been identified as the crucial factor that could enhance customer capital (Innis and La Londe 1994; Daugherty, Stank, and Ellinger 1998; Stank et al. 2003) and consecutively affect improvement in market share, as well as profitability, of organisations (Anderson, Fornell, and Lehmann 1994; Leuthesser and Kohli 1995). Therefore, studies related to logistics mostly consider the measurement and management of organisational capital along several dimensions, including infrastructure, culture, and process. From the review process, it was clear that 97% of the reviewed studies mentioned or applied either only organisational capital measures or organisational capital measures integrated with other IC measures. All organisational indicators in logistics are presented in Table 6.

Table 6 presents the measures of organisational capital that have application frequency of more than four times, and to reduce the length of the article, the measures adopted less than three times in the reviewed articles are presented as follows: information systems flexibility (Cai et al. 2009; Kim, Kumar, and Kumar 2010; Anand and Grover 2015), oper-

Table 4. Measures of relationships from reviewed articles.

Measures (No. of publication)	Author(s)
Customer service level (37)	Shang and Marlow (2005), Lai, Ngai, and Cheng (2002), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Ramanathan (2010), Hwang, Chen, and Lin (2016), Mbaga et al. (2011), Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and Mohamed (2009), Kunadhamraks and Hanaoka (2008), Varsei et al. (2014), Arlbjørn and Lüthje (2012), Soni and Kodali (2010), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Aramyan et al. (2007), Chia, Goh, and Hum (2009), Bigliardi and Bottani (2010), Morgan (2004), Ramanathan, Gunasekaran, and Subramanian (2011), Jothimani and Sarmah (2014), Thakkar, Kanda, and Deshmukh (2009), Najmi and Makui (2012), Elrod, Murray, and Bande (2013), Blome, Schoenherr, and Rexhausen (2013), Mothilal et al. (2012), Lu and Yang (2010), Sha and Chen (2008), Kilibarda, Zečević, and Vidović (2012), Huang et al. (2012), Gunasekaran and Kobu (2007), Seth, Deshmukh, and Vrat (2006), Lai and Cheng (2003), Huang and Huang (2012), Zailani et al. (2015), Golrizgashti (2014)
Satisfaction of customers or partners (35)	Garcia et al. (2012), Shaik and Abdul-Kader (2014), Krakovics et al. (2008), Fawcett and Cooper (1998), Cai et al. (2009), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Chan et al. (2003), Caplice and Sheffi (1995), Saad and Patel (2006), Wang, Jie, and Abareshi (2015), Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and Mohamed (2009), Su, Fang, and Young (2013), Zaman and Ahsan (2014), Keebler and Plank (2009), Chow, Heaver, and Henriksson (1994), Piecyk and Björklund (2015), Anand and Grover (2015), Shepherd and Günter (2011), Aramyan et al. (2007), Chia, Goh, and Hum (2009), Shaik and Abdul-Kader (2012), Barbosa and Musetti (2011), Elrod, Murray, and Bande (2013), Blome, Schoenherr, and Rexhausen (2013), Mothilal et al. (2012), Lu and Yang (2010), Panayides (2004), Liang (2015), Vlachos (2016), Karia and Wong (2013), Shaik and Abdul-Kader (2013), Staudt et al. (2015), Chan (2003)
Relationship and partnership level (29)	Bansia, Varkey, and Agrawal (2014), Bhagwat and Sharma (2007a, 2007b), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Aguezzoul (2014), Li, Wu, and Holsapple (2015), Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Su, Fang, and Young (2013), Soni and Kodali (2010), Zaman and Ahsan (2014), Shepherd and Günter (2011), Bigliardi and Bottani (2010), Shaik and Abdul-Kader (2012), Elrod, Murray, and Bande (2013), Bhagwat and Sharma (2009), Blome, Schoenherr, and Rexhausen (2013), Shen and Chou (2010), Dey and Cheffi (2013), Mothilal et al. (2012), Lu and Yang (2010), Huang et al. (2012), Liang (2015), Bai and Sarkis (2012), Yang (2009), Karia and Wong (2013), Golrizgashti (2014)
Customer query time (24)	Gunasekaran, Patel, and McGaughey (2004), Fawcett and Cooper (1998), Shang and Marlow (2005), Lai, Ngai, and Cheng (2002), Bhagwat and Sharma (2007a, 2007b), Shafiee, Lotfi, and Saleh (2014), Chan et al. (2003), Wang, Jie, and Abareshi (2015), Sambasivan, Nandan, and Mohamed (2009), Arlbjørn and Lüthje (2012), Keebler and Plank (2009), Shepherd and Günter (2011), Beamon (1999), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010), Aramyan et al. (2007), Bigliardi and Bottani (2010), Morgan (2004), Bhagwat and Sharma (2009), Seth, Deshmukh, and Vrat (2006), Lai and Cheng (2003), Chan (2003), Golrizgashti (2014)
Responsiveness and solutions for customers (23)	Fawcett and Cooper (1998), Lai, Ngai, and Cheng (2002), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Hwang, Chen, and Lin (2016), Papakiriakopoulos and Pramatari (2010), Kunadhamraks and Hanaoka (2008), Soni and Kodali (2010), Zaman and Ahsan (2014), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Jothimani and Sarmah (2014), Wong et al. (2014), Lu and Yang (2010), Panayides (2004), Liang (2015), Seth, Deshmukh, and Vrat (2006), Lin (2007), Lai and Cheng (2003), Karia and Wong (2013), Huang and Huang (2012), Zailani et al. (2015), Golrizgashti (2014)
Rates of customer complaints (16)	Fawcett and Cooper (1998), Cai et al. (2009), Caplice and Sheffi (1995), Wang, Jie, and Abareshi (2015), Sambasivan, Nandan, and Mohamed (2009), Keebler and Plank (2009), Anand and Grover (2015), Shepherd and Günter (2011), Beamon (1999), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010),

(*Continued*)

Table 4. (*Continued*)

Measures (No. of publication)	Author(s)
Service variety (15)	Aramyan et al. (2007), Morgan (2004), Ramanathan, Gunasekaran, and Subramanian (2011), Najmi and Makui (2012), Huang et al. (2012) Gunasekaran, Patel, and McGaughey (2004), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Aguezzoul (2014), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Soni and Kodali (2010), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Elrod, Murray, and Bande (2013), Panayides (2004), Huang et al. (2012), Gunasekaran and Kobu (2007), Bai and Sarkis (2012), Golrizgashti (2014)
Customer loyalty (13)	Fawcett and Cooper (1998), Giovanis, Tomaras, and Zondiros (2013), Shafiee, Lotfi, and Saleh (2014), Ramanathan (2010), Wu and Chou (2007), Holmberg (2000), Sambasivan, Nandan, and Mohamed (2009), Banomyong and Supatn (2011), Hervani, Helms, and Sarkis (2005), Aramyan et al. (2007), Chia, Goh, and Hum (2009), Huang et al. (2012), Golrizgashti (2014)
Flexibility of service systems to meet particular customer needs (12)	Gunasekaran, Patel, and McGaughey (2004), Alkhatib et al. (2015), Bhagwat and Sharma (2007a, 2007b), Shafiee, Lotfi, and Saleh (2014), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Arlbjørn and Lüthje (2012), Shepherd and Günter (2011), Bhagwat and Sharma (2009), Seth, Deshmukh, and Vrat (2006), Huang and Huang (2012)
Corporate image and reputation (11)	Shaik and Abdul-Kader (2014), Giovanis, Tomaras, and Zondiros (2013), Shafiee, Lotfi, and Saleh (2014), Aguezzoul (2014), Hwang, Chen, and Lin (2016), Wang, Jie, and Abareshi (2015), Sambasivan, Nandan, and Mohamed (2009), Hervani, Helms, and Sarkis (2005), Shaik and Abdul-Kader (2012), Panayides (2004), Huang et al. (2012)
Rate of customer's claims (10)	Fawcett and Cooper (1998), Shafiee, Lotfi, and Saleh (2014), Sambasivan, Nandan, and Mohamed (2009), Banomyong and Supatn (2011), Su, Fang, and Young (2013), Vaidya and Hudnurkar (2013), Hervani, Helms, and Sarkis (2005), Morgan (2004), Sellitto et al. (2015), Golrizgashti (2014)
Market share (8)	Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Wu and Chou (2007), Sambasivan, Nandan, and Mohamed (2009), Vaidya and Hudnurkar (2013), Aramyan et al. (2007), Chia, Goh, and Hum (2009), Golrizgashti (2014)
Extent of mutual co-operation leading to improved quality or problem solving (8)	Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Soni and Kodali (2010), Zaman and Ahsan (2014), Shepherd and Günter (2011), Bhagwat and Sharma (2009), Bhagwat and Sharma (2007b), Bai and Sarkis (2012)
Ability of collaboration among partners (8)	Jakhar (2015), Shafiee, Lotfi, and Saleh (2014), Mbaga et al. (2011), Sambasivan, Nandan, and Mohamed (2009), Sha and Chen (2008), Huang et al. (2012), Liang (2015), Golrizgashti (2014)
Trust and commitment with partners (8)	Giovanis, Tomaras, and Zondiros (2013), Shafiee, Lotfi, and Saleh (2014), Bai and Sarkis (2014), Shepherd and Günter (2011), Blome, Schoenherr, and Rexhausen (2013), Bai and Sarkis (2012), Yang (2009), Karia and Wong (2013)
Decision synchronisation (5)	Anand and Grover (2015), Ramanathan, Gunasekaran, and Subramanian (2011), Sha and Chen (2008), Karia and Wong (2013), Jeenanunta, Ueki, and Visanvetchakij (2013)
Claims management capability (3)	Ramanathan (2010), Sambasivan, Nandan, and Mohamed (2009), Huang and Huang (2012)
Alliance performance (1)	Yang (2009)
Social responsibility (1)	Mbaga et al. (2011)

ational flexibility (Shang and Marlow 2005; Mbaga et al. 2011; Najmi and Makui 2012), order accuracy rate (Fawcett and Cooper 1998; Banomyong and Supatn 2011; Giovanis, Tomaras, and Zondiros 2013), finished goods in transit (Shepherd and Günter 2011; Vlajic et al. 2013; Shafiee, Lotfi, and Saleh 2014), supplier selection and evaluation (Gunasekaran, Patel, and McGaughey 2004; Bigliardi and Bottani 2010; Blome, Schoenherr, and Rexhausen 2013), transport flexibility (Shepherd and Günter 2011; Golrizgashti 2014; Jothimani and Sarmah 2014), transport capacity (Morgan 2004; Shaik and Abdul-Kader 2012, 2014), warehousing performance index (Keebler and Plank 2009; Garcia et al. 2012; Staudt et al. 2015), number of warehousing facilities (Reiner and Hofmann 2006; Aguezzoul 2014; Anand and Grover 2015), recycling of materials (Hervani, Helms, and Sarkis 2005; Dey and Cheffi 2013; Golrizgashti 2014), overall environmental compliance (Shaik and Abdul-Kader 2012, 2013, 2014), picking and shipping accuracy (Abrahamsson and Aronsson 1999; Morgan 2004), data security (Sambasivan, Nandan, and Mohamed 2009; Hwang, Chen,

Table 5. Measures of renewal and development from reviewed articles.

Measures (No. of publication)	Author(s)
Innovation capability (22)	Shaik and Abdul-Kader (2014), Shafiee, Lotfi, and Saleh (2014), Wu and Chou (2007), Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Anand and Grover (2015), Vaidya and Hudnurkar (2013), Chia, Goh, and Hum (2009), Thakkar, Kanda, and Deshmukh (2009), Yang (2012), Ramos (2004), Dey and Cheffi (2013), Lu and Yang (2010), Sha and Chen (2008), Huang et al. (2012), Vlachos (2016), Seth, Deshmukh, and Vrat (2006), Bai and Sarkis (2012), Huang and Huang (2012), Chan (2003), Golrizgashti (2014)
New product/service time to market or time to volume (8)	Shafiee, Lotfi, and Saleh (2014), Caplice and Sheffi (1995), Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Shepherd and Günter (2011), Ramos (2004), Sha and Chen (2008), Golrizgashti (2014)
Use of new technology and innovation (6)	Guarnieri et al. (2015), Soni and Kodali (2010), Huang and Huang (2012), Zailani et al. (2015), Chan (2003), Golrizgashti (2014)
New product/service flexibility (4)	Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Beamon (1999), Chan (2003)
Rate of changes (2)	Domingues, Reis, and Macário (2015), Huang et al. (2012)
Research and development ratio (1)	Bai et al. (2012)
Inability to meet future requirement (1)	Bai et al. (2012)

and Lin 2016), integration of information systems or IT (Lu and Yang 2010; Blome, Schoenherr, and Rexhausen 2013), compliance with the latest regulations (Gunasekaran and Kobu 2007; Anand and Grover 2015), advance equipment and facilities (Huang and Huang 2012; Karia and Wong 2013), level of integration technology (Guarnieri et al. 2015; Shang and Marlow 2005), rate of delivery of raw materials (Huang et al. 2012; Shafiee, Lotfi, and Saleh 2014), urgent order fulfilment rate (Huang et al. 2012; Yogi 2015), order flexibility (Gunasekaran, Patel, and McGaughey 2004; Arlbjørn and Lüthje 2012), orders per sales representative (Fawcett and Cooper 1998; Vaidya and Hudnurkar 2013), order tracking performance (Sha and Chen 2008; Shafiee, Lotfi, and Saleh 2014), responsiveness to urgent orders (Shafiee, Lotfi, and Saleh 2014; Wong et al. 2014), resource utilisation (Chan et al. 2003; Lai and Cheng 2003), cargo theft (Krakovics et al. 2008; Domingues, Reis, and Macário 2015), operating efficiency (Panayides 2004; Krakovics et al. 2008), delivery consistency (Fawcett and Cooper 1998; Shang and Marlow 2005), days of sales outstanding (Aguezzoul 2014; Anand and Grover 2015), days payable outstanding (Aguezzoul 2014; Anand and Grover 2015), purchase quantity (Abrahamsson and Aronsson 1999; Soni and Kodali 2010), procurement flexibility (Cai et al. 2009; Blome, Schoenherr, and Rexhausen 2013), reverse logistics cycle time (Huang and Huang 2012; Shaik and Abdul-Kader 2012), capacity utilisation of transportation (Garcia et al. 2012; Vaidya and Hudnurkar 2013), geographical coverage of transportation (Jothimani and Sarmah 2014; Zailani et al. 2015), number of community projects supported (Golrizgashti 2014; Piecyk and Björklund 2015), community complaints (Hervani, Helms, and Sarkis 2005; Shaik and Abdul-Kader 2013), IT system scalability (Hwang, Chen, and Lin 2016), IT system stability (Hwang, Chen, and Lin 2016), technology renewal intensity (Huang et al. 2012), discrepancy handling (Giovanis, Tomaras, and Zondiros 2013), transportation labour productivity (Fawcett and Cooper 1998), steady supply of finished product (Shafiee, Lotfi, and Saleh 2014), last mile connectivity (Anand and Grover 2015), right equipment supply (Brooks 1999), equipment upgrade intensity (Huang et al. 2012), system flexibility index (Guarnieri et al. 2015), warehouse labour productivity (Fawcett and Cooper 1998), percentage of time spent picking back orders (Anand and Grover 2015), average order size (Soni and Kodali 2010), repair centre capability (Guarnieri et al. 2015), effective reverse logistics (Dey and Cheffi 2013), state-of-the-art design of sustainable reverse logistics (Dey and Cheffi 2013), carrier reliability (Jothimani and Sarmah 2014), warehouse handling quality index (Jothimani and Sarmah 2014), storage accuracy (Staudt et al. 2015), and environmental reward systems and evaluation schemes (Dey and Cheffi 2013).

Table 6 and the earlier discussion demonstrate that there are numerous organisational measures that are frequently applied in studies related to logistics. Especially when compared to other IC dimensions, these intangible measures are the most applied indicators; therefore, this outcome also conforms to past research (Gunasekaran and Kobu 2007), indicating that around half of all KPIs are organisational process measures that are significant factors affecting the operational performance of an organisation. Additionally, Table 6 also presents the highest frequency of the employed measures, which is on-time or out-of-date delivery performance. This indicator is an internal process performance measurement that is often applied in studies related to organisational capital, and all reviewed logistics articles, around 49 and 47%, respectively. Moreover, there are several indicators of organisational capital performance that were broadly

Table 6. Organisational measures from reviewed articles.

Measures (No. of publications)	Author(s)
On-time or out-of-date delivery performance (53)	Domingues, Reis, and Macário (2015), Gunasekaran, Patel, and McGaughey (2004), Krakovics et al. (2008), Fawcett and Cooper (1998), Shang and Marlow (2005), Lai, Ngai, and Cheng (2002), Cai et al. (2009), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Ramanathan (2010), Aguezzoul (2014), Hwang, Chen, and Lin (2016), Chan et al. (2003), Caplice and Sheffi (1995), Holmberg (2000), Li, Wu, and Holsapple (2015), Wang, Jie, and Abareshi (2015), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Chae (2009), Soni and Kodali (2010), Keebler and Plank (2009), Chow, Heaver, and Henriksson (1994), Anand and Grover (2015), Shepherd and Günter (2011), Beamon (1999), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010), Chia, Goh, and Hum (2009), Bigliardi and Bottani (2010), Cuthbertson and Piotrowicz (2011), Morgan (2004), Jothimani and Sarmah (2014), Thakkar, Kanda, and Deshmukh (2009), Najmi and Makui (2012), Sellitto et al. (2015), Wang et al. (2008), Ramos (2004), Reiner and Hofmann (2006), Mothilal et al. (2012), Lu and Yang (2010), Abrahamsson and Aronsson (1999), Huang et al. (2012), Brooks (1999), Bai and Sarkis (2012), Huang and Huang (2012), Staudt et al. (2015), Kocaoğlu, Gülsün, and Tanyaş (2013), Chan (2003), Jeenanunta, Ueki, and Visanvetchakij (2013), Golrizgashti (2014)
Order fill rate (38)	Domingues, Reis, and Macário (2015), Garcia et al. (2012), Gunasekaran, Patel, and McGaughey (2004), Turi, Goncalves, and Mocan (2014), Krakovics et al. (2008), Fawcett and Cooper (1998), Lai, Ngai, and Cheng (2002), Cai et al. (2009), Shafiee, Lotfi, and Saleh (2014), Wibowo and Sholeh (2015), Guarnieri et al. (2015), Chan et al. (2003), Caplice and Sheffi (1995), Gulledge and Chavusholu (2008), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Chae (2009), Arlbjørn and Lüthje (2012), Soni and Kodali (2010), Solakivi et al. (2011), Keebler and Plank (2009), Anand and Grover (2015), Beamon (1999), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010), Aramyan et al. (2007), Jothimani and Sarmah (2014), Thakkar, Kanda, and Deshmukh (2009), Barbosa and Musetti (2011), Najmi and Makui (2012), Reiner and Hofmann (2006), Lin (2007), Lai and Cheng (2003), Thunberg and Persson (2014), Vlajic et al. (2013), Staudt et al. (2015), Kocaoğlu, Gülsün, and Tanyaş (2013), Chan (2003)
Inventory level and condition (36)	Garcia et al. (2012), Giovanis, Tomaras, and Zondiros (2013), Shafiee, Lotfi, and Saleh (2014), Wibowo and Sholeh (2015), Aguezzoul (2014), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Banomyong and Supatn (2011), Chae (2009), Bai et al. (2012), Soni and Kodali (2010), Solakivi et al. (2011), Chow, Heaver, and Henriksson (1994), Anand and Grover (2015), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010), Hervani, Helms, and Sarkis (2005), Aramyan et al. (2007), Cuthbertson and Piotrowicz (2011), Ramanathan, Gunasekaran, and Subramanian (2011), Jothimani and Sarmah (2014), Najmi and Makui (2012), Sellitto et al. (2015), Reiner and Hofmann (2006), Dey and Cheffi (2013), Abrahamsson and Aronsson (1999), Yogi (2015), Bai and Sarkis (2012), Schramm-Klein and Morschett (2006), Vlajic et al. (2013), Hofmann and Locker (2009), Kocaoğlu, Gülsün, and Tanyaş (2013), Mishra and Sharma (2014), Zailani et al. (2015)
Delivery time or speed (33)	Domingues, Reis, and Macário (2015), Jakhar (2015), Bhagwat and Sharma (2007a, 2007b), Shafiee, Lotfi, and Saleh (2014), Aguezzoul (2014), Caplice and Sheffi (1995), Sambasivan, Nandan, and Mohamed (2009), Banomyong and Supatn (2011), Kunadhamraks and Hanaoka (2008), Zaman and Ahsan (2014), Solakivi et al. (2011), Anand and Grover (2015), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Cuthbertson and Piotrowicz (2011), Morgan (2004), Green, Whitten, and Inman (2008), Najmi and Makui (2012), Bhagwat and Sharma (2009), Blome, Schoenherr, and Rexhausen (2013), Wong et al. (2014), Lu and Yang (2010), Sha and Chen (2008), Kilibarda, Zečević, and Vidović (2012), Lin (2007), Huang and Huang (2012), Schramm-Klein and Morschett (2006), Thunberg and Persson (2014), Staudt et al. (2015), Jakhar (2014), Golrizgashti (2014)
Information and documentation accuracy (31)	Gunasekaran, Patel, and McGaughey (2004), Bansia, Varkey, and Agrawal (2014), Fawcett and Cooper (1998), Shang and Marlow (2005), Lai, Ngai, and Cheng (2002), Cai et al. (2009), Bhagwat and Sharma (2007a), Giovanis, Tomaras, and Zondiros (2013), Shafiee, Lotfi, and Saleh (2014), Hwang, Chen, and Lin (2016), Wang, Jie, and Abareshi (2015), Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and

(*Continued*)

Table 6. (*Continued*)

Measures (No. of publications)	Author(s)
	Mohamed (2009), Bai and Sarkis (2014), Solakivi et al. (2011), Keebler and Plank (2009), Anand and Grover (2015), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Morgan (2004), Ramanathan, Gunasekaran, and Subramanian (2011), Jothimani and Sarmah (2014), Thakkar, Kanda, and Deshmukh (2009), Elrod, Murray, and Bande (2013), Huang et al. (2012), Brooks (1999), Liang (2015), Lai and Cheng (2003), Bai and Sarkis (2012), Golrizgashti (2014)
Level of information sharing (27)	Alkhatib et al. (2015), Shang and Marlow (2005), Cai et al. (2009), Shafiee, Lotfi, and Saleh (2014), Mbaga et al. (2011), Chan et al. (2003), Li, Wu, and Holsapple (2015), Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Su, Fang, and Young (2013), Soni and Kodali (2010), Anand and Grover (2015), Shepherd and Günter (2011), Morgan (2004), Ramanathan, Gunasekaran, and Subramanian (2011), Thakkar, Kanda, and Deshmukh (2009), Najmi and Makui (2012), Yang (2012), Panayides (2004), Liang (2015), Seth, Deshmukh, and Vrat (2006), Bai and Sarkis (2012), Yang (2009), Karia and Wong (2013), Jeenanunta, Ueki, and Visanvetchakij (2013), Golrizgashti (2014)
Order lead time (23)	Gunasekaran, Patel, and McGaughey (2004), Cai et al. (2009), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Wibowo and Sholeh (2015), Chan et al. (2003), Gulledge and Chavusholu (2008), Sambasivan, Nandan, and Mohamed (2009), Arlbjørn and Lüthje (2012), Soni and Kodali (2010), Vaidya and Hudnurkar (2013), Aramyan et al. (2007), Bigliardi and Bottani (2010), Jothimani and Sarmah (2014), Najmi and Makui (2012), Elrod, Murray, and Bande (2013), Reiner and Hofmann (2006), Yogi (2015), Vlajic et al. (2013), Hofmann and Locker (2009), Staudt et al. (2015), Kocaoğlu, Gülsün, and Tanyaş (2013), Golrizgashti (2014)
Flexibility rate (22)	Gunasekaran, Patel, and McGaughey (2004), Cai et al. (2009), Shafiee, Lotfi, and Saleh (2014), Aguezzoul (2014), Mbaga et al. (2011), Chan et al. (2003), Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Chow, Heaver, and Henriksson (1994), Kim, Kumar, and Kumar (2010), Bigliardi and Bottani (2010), Green, Whitten, and Inman (2008), Elrod, Murray, and Bande (2013), Lu and Yang (2010), Sha and Chen (2008), Huang et al. (2012), Liang (2015), Huang and Huang (2012), Jakhar (2014), Chan (2003), Golrizgashti (2014)
Inventory turnover (21)	Garcia et al. (2012), Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Keebler and Plank (2009), Anand and Grover (2015), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Cuthbertson and Piotrowicz (2011), Morgan (2004), Thakkar, Kanda, and Deshmukh (2009), Barbosa and Musetti (2011), Najmi and Makui (2012), Wang et al. (2008), Shen and Chou (2010), Ramos (2004), Sha and Chen (2008), Huang et al. (2012), Liang (2015), Schramm-Klein and Morschett (2006), Staudt et al. (2015)
Environmental index (21)	Turi, Goncalves, and Mocan (2014), Jakhar (2015), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Mbaga et al. (2011), Lau (2011), Bai et al. (2012), Varsei et al. (2014), Piecyk and Björklund (2015), Anand and Grover (2015), Hervani, Helms, and Sarkis (2005), Aramyan et al. (2007), Chia, Goh, and Hum (2009), Cuthbertson and Piotrowicz (2011), Sellitto et al. (2015), Wang et al. (2008), Sha and Chen (2008), Huang et al. (2012), Liang (2015), Jakhar (2014), Golrizgashti (2014)
Delivery efficiency (20)	Garcia et al. (2012), Turi, Goncalves, and Mocan (2014), Shafiee, Lotfi, and Saleh (2014), Keebler and Plank (2009), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Morgan (2004), Barbosa and Musetti (2011), Wang et al. (2008), Wong et al. (2014), Ramos (2004), Abrahamsson and Aronsson (1999), Huang et al. (2012), Brooks (1999), Huang and Huang (2012), Schramm-Klein and Morschett (2006), Shaik and Abdul-Kader (2013), Staudt et al. (2015), Chan (2003), Golrizgashti (2014)
Delivery reliability (19)	Gunasekaran, Patel, and McGaughey (2004), Jakhar (2015), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Arlbjørn and Lüthje (2012), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Lu and Yang (2010), Gunasekaran and Kobu (2007), Seth, Deshmukh, and Vrat (2006), Bai and Sarkis (2012), Schramm-Klein and Morschett (2006), Jakhar (2014), Zailani et al. (2015), Golrizgashti (2014)
Capacity utilisation (19)	Garcia et al. (2012), Gunasekaran, Patel, and McGaughey (2004), Chan et al. (2003), Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Anand and Grover (2015), Shepherd and Günter (2011), Bigliardi and Bottani (2010), Ramanathan,

(*Continued*)

Table 6. (*Continued*)

Measures (No. of publications)	Author(s)
	Gunasekaran, and Subramanian (2011), Jothimani and Sarmah (2014), Najmi and Makui (2012), Elrod, Murray, and Bande (2013), Bhagwat and Sharma (2009), Sha and Chen (2008), Gunasekaran and Kobu (2007), Bhagwat and Sharma (2007b), Jakhar (2014), Chan (2003), Golrizgashti (2014)
Transportation safety rate (19)	Domingues, Reis, and Macário (2015), Krakovics et al. (2008), Fawcett and Cooper (1998), Bhagwat and Sharma (2007a), Hwang, Chen, and Lin (2016), Mbaga et al. (2011), Caplice and Sheffi (1995), Wang, Jie, and Abareshi (2015), Sambasivan, Nandan, and Mohamed (2009), Banomyong and Supatn (2011), Kunadhamraks and Hanaoka (2008), Piecyk and Björklund (2015), Anand and Grover (2015), Vaidya and Hudnurkar (2013), Hervani, Helms, and Sarkis (2005), Cuthbertson and Piotrowicz (2011), Barbosa and Musetti (2011), Dey and Cheffi (2013), Huang and Huang (2012)
Forecast accuracy (18)	Garcia et al. (2012), Bhagwat and Sharma (2007a, 2007b), Shafiee, Lotfi, and Saleh (2014), Mbaga et al. (2011), Caplice and Sheffi (1995), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Chae (2009), Soni and Kodali (2010), Zaman and Ahsan (2014), Keebler and Plank (2009), Vaidya and Hudnurkar (2013), Ramanathan, Gunasekaran, and Subramanian (2011), Bhagwat and Sharma (2009), Gunasekaran and Kobu (2007), Hofmann and Locker (2009), Golrizgashti (2014)
Rates/probability of stockouts (18)	Garcia et al. (2012), Fawcett and Cooper (1998), Cai et al. (2009), Shafiee, Lotfi, and Saleh (2014), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Banomyong and Supatn (2011), Soni and Kodali (2010), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010), Morgan (2004), Ramanathan, Gunasekaran, and Subramanian (2011), Barbosa and Musetti (2011), Abrahamsson and Aronsson (1999), Vlajic et al. (2013), Staudt et al. (2015), Chan (2003)
Cycle time (18)	Domingues, Reis, and Macário (2015), Bansia, Varkey, and Agrawal (2014), Fawcett and Cooper (1998), Bhagwat and Sharma (2007a, 2007b), Guarnieri et al. (2015), Caplice and Sheffi (1995), Sambasivan, Nandan, and Mohamed (2009), Banomyong and Supatn (2011), Soni and Kodali (2010), Keebler and Plank (2009), Vaidya and Hudnurkar (2013), Barbosa and Musetti (2011), Bhagwat and Sharma (2009), Wong et al. (2014), Brooks (1999), Schramm-Klein and Morschett (2006), Golrizgashti (2014)
Productivity rate (16)	Domingues, Reis, and Macário (2015), Garcia et al. (2012), Fawcett and Cooper (1998), Caplice and Sheffi (1995), Sambasivan, Nandan, and Mohamed (2009), Kunadhamraks and Hanaoka (2008), Shepherd and Günter (2011), Morgan (2004), Jothimani and Sarmah (2014), Barbosa and Musetti (2011), Abrahamsson and Aronsson (1999), Sha and Chen (2008), Huang et al. (2012), Gunasekaran and Kobu (2007), Staudt et al. (2015), Kocaoğlu, Gülsün, and Tanyaş (2013)
Use of information technology (16)	Alkhatib et al. (2015), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Aguezzoul (2014), Wu and Chou (2007), Sambasivan, Nandan, and Mohamed (2009), Chae (2009), Kunadhamraks and Hanaoka (2008), Anand and Grover (2015), Shen and Chou (2010), Huang et al. (2012), Vlachos (2016), Seth, Deshmukh, and Vrat (2006), Karia and Wong (2013), Shaik and Abdul-Kader (2013), Golrizgashti (2014)
Delivery flexibility (15)	Cai et al. (2009), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Anand and Grover (2015), Shepherd and Günter (2011), Beamon (1999), Aramyan et al. (2007), Bigliardi and Bottani (2010), Green, Whitten, and Inman (2008), Elrod, Murray, and Bande (2013), Blome, Schoenherr, and Rexhausen (2013), Schramm-Klein and Morschett (2006), Chan (2003)
Effectiveness of planning schedule (13)	Gunasekaran, Patel, and McGaughey (2004), Krakovics et al. (2008), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Sambasivan, Nandan, and Mohamed (2009), Keebler and Plank (2009), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Ramanathan, Gunasekaran, and Subramanian (2011), Elrod, Murray, and Bande (2013), Gunasekaran and Kobu (2007), Golrizgashti (2014)
Shipping errors or shipment error rate (13)	Fawcett and Cooper (1998), Hwang, Chen, and Lin (2016), Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Anand and Grover (2015), Shepherd and Günter (2011), Beamon (1999), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010), Aramyan et al. (2007), Cuthbertson and Piotrowicz (2011), Elrod, Murray, and Bande (2013), Lin (2007)
Distribution performance (12)	

(*Continued*)

Table 6. (*Continued*)

Measures (No. of publications)	Author(s)
	Domingues, Reis, and Macário (2015), Fawcett and Cooper (1998), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Sambasivan, Nandan, and Mohamed (2009), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Morgan (2004), Huang et al. (2012), Staudt et al. (2015), Golrizgashti (2014)
Number of backorders (11)	Shafiee, Lotfi, and Saleh (2014), Keebler and Plank (2009), Anand and Grover (2015), Shepherd and Günter (2011), Beamon (1999), Vaidya and Hudnurkar (2013), Kim, Kumar, and Kumar (2010), Aramyan et al. (2007), Cuthbertson and Piotrowicz (2011), Morgan (2004), Vlajic et al. (2013)
ISO or quality compliance (11)	Giovanis, Tomaras, and Zondiros (2013), Guarnieri et al. (2015), Hwang, Chen, and Lin (2016), Mbaga et al. (2011), Chan et al. (2003), Holmberg (2000), Anand and Grover (2015), Vaidya and Hudnurkar (2013), Cuthbertson and Piotrowicz (2011), Dey and Cheffi (2013), Gunasekaran and Kobu (2007)
Improvement capability (10)	Fawcett and Cooper (1998), Shang and Marlow (2005), Cai et al. (2009), Hwang, Chen, and Lin (2016), Blome, Schoenherr, and Rexhausen (2013), Dey and Cheffi (2013), Lu and Yang (2010), Huang et al. (2012), Karia and Wong (2013), Huang and Huang (2012)
Volume flexibility (10)	Shafiee, Lotfi, and Saleh (2014), Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Shepherd and Günter (2011), Beamon (1999), Vaidya and Hudnurkar (2013), Aramyan et al. (2007), Elrod, Murray, and Bande (2013), Lu and Yang (2010), Sha and Chen (2008)
Purchase order cycle time (10)	Gunasekaran, Patel, and McGaughey (2004), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Bai and Sarkis (2014), Arlbjørn and Lüthje (2012), Zaman and Ahsan (2014), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Bai and Sarkis (2012), Golrizgashti (2014)
Obsolete inventory (10)	Garcia et al. (2012), Shafiee, Lotfi, and Saleh (2014), Chae (2009), Soni and Kodali (2010), Keebler and Plank (2009), Anand and Grover (2015), Shepherd and Günter (2011), Kim, Kumar, and Kumar (2010), Barbosa and Musetti (2011), Elrod, Murray, and Bande (2013)
Information technology and information system capability (10)	Shaik and Abdul-Kader (2014), Guarnieri et al. (2015), Aguezzoul (2014), Hwang, Chen, and Lin (2016), Mbaga et al. (2011), Anand and Grover (2015), Aramyan et al. (2007), Lu and Yang (2010), Karia and Wong (2013), Huang and Huang (2012)
Technological capability levels (9)	Mbaga et al. (2011), Bai and Sarkis (2014), Anand and Grover (2015), Vaidya and Hudnurkar (2013), Shaik and Abdul-Kader (2012), Ramanathan, Gunasekaran, and Subramanian (2011), Lu and Yang (2010), Bai and Sarkis (2012), Karia and Wong (2013)
Quality rate (9)	Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Shepherd and Günter (2011), Blome, Schoenherr, and Rexhausen (2013), Mothilal et al. (2012), Lu and Yang (2010), Abrahamsson and Aronsson (1999), Huang et al. (2012), Bai and Sarkis (2012)
Inventory accuracy (8)	Garcia et al. (2012), Krakovics et al. (2008), Shafiee, Lotfi, and Saleh (2014), Keebler and Plank (2009), Anand and Grover (2015), Shepherd and Günter (2011), Jothimani and Sarmah (2014), Staudt et al. (2015)
Equipment productivity (8)	Fawcett and Cooper (1998), Sambasivan, Nandan, and Mohamed (2009), Keebler and Plank (2009), Vaidya and Hudnurkar (2013), Morgan (2004), Moreira and Tjahjono (2016), Brooks (1999), Staudt et al. (2015)
Order entry methods (7)	Gunasekaran, Patel, and McGaughey (2004), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Sambasivan, Nandan, and Mohamed (2009), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Golrizgashti (2014)
Utilisation rate (7)	Sambasivan, Nandan, and Mohamed (2009), Soni and Kodali (2010), Keebler and Plank (2009), Moreira and Tjahjono (2016), Dey and Cheffi (2013), Huang et al. (2012), Chan (2003)
Number of order status type (7)	Garcia et al. (2012), Sellitto et al. (2015), Shen and Chou (2010), Abrahamsson and Aronsson (1999), Huang et al. (2012), Yogi (2015), Vlajic et al. (2013)
Reduction of emissions (7)	Turi, Goncalves, and Mocan (2014), Aguezzoul (2014), Anand and Grover (2015), Hervani, Helms, and Sarkis (2005), Moreira and Tjahjono (2016), Dey and Cheffi (2013), Jakhar (2014)
Information timeliness (7)	Shang and Marlow (2005), Cai et al. (2009), Bai and Sarkis (2014), Anand and Grover (2015), Shepherd and Günter (2011), Liang (2015), Bai and Sarkis (2012)
Warehouse space utilisation (6)	Keebler and Plank (2009), Anand and Grover (2015), Jothimani and Sarmah (2014), Wong et al. (2014), Huang et al. (2012), Staudt et al. (2015)
Information availability (6)	

(*Continued*)

Table 6. (*Continued*)

Measures (No. of publications)	Author(s)
	Fawcett and Cooper (1998), Cai et al. (2009), Sambasivan, Nandan, and Mohamed (2009), Bai and Sarkis (2014), Shepherd and Günter (2011), Bai and Sarkis (2012)
Energy efficiency and utilisation (6)	Turi, Goncalves, and Mocan (2014), Shaik and Abdul-Kader (2014), Bansia, Varkey, and Agrawal (2014), Bai et al. (2012), Shaik and Abdul-Kader (2012), Chan (2003)
Timeliness in operation (5)	Giovanis, Tomaras, and Zondiros (2013), Soni and Kodali (2010), Vaidya and Hudnurkar (2013), Liang (2015), Seth, Deshmukh, and Vrat (2006)
Reliability (5)	Fawcett and Cooper (1998), Papakiriakopoulos and Pramatari (2010), Sambasivan, Nandan, and Mohamed (2009), Morgan (2004), Schramm-Klein and Morschett (2006)
Supplier's booking-in procedures (5)	Bai and Sarkis (2014), Soni and Kodali (2010), Shepherd and Günter (2011), Vaidya and Hudnurkar (2013), Bai and Sarkis (2012)
Cargo damage rate (5)	Garcia et al. (2012), Morgan (2004), Jothimani and Sarmah (2014), Kilibarda, Zečević, and Vidović (2012), Staudt et al. (2015)
Levels of environmental responsibilities (5)	Turi, Goncalves, and Mocan (2014), Hervani, Helms, and Sarkis (2005), Dey and Cheffi (2013), Karia and Wong (2013), Golrizgashti (2014)
Responsiveness (5)	Okongwu, Brulhart, and Moncef (2015), Sambasivan, Nandan, and Mohamed (2009), Thakkar, Kanda, and Deshmukh (2009), Green, Whitten, and Inman (2008), Moreira and Tjahjono (2016)
Customer order path (5)	Gunasekaran, Patel, and McGaughey (2004), Sambasivan, Nandan, and Mohamed (2009), Vaidya and Hudnurkar (2013), Bigliardi and Bottani (2010), Elrod, Murray, and Bande (2013)
Order condition (5)	Fawcett and Cooper (1998), Giovanis, Tomaras, and Zondiros (2013), Shafiee, Lotfi, and Saleh (2014), Guarnieri et al. (2015), Papakiriakopoulos and Pramatari (2010)
Equipment utilisation/capacity (5)	Bansia, Varkey, and Agrawal (2014), Keebler and Plank (2009), Vaidya and Hudnurkar (2013), Jothimani and Sarmah (2014), Chan (2003)
Delivery frequency (5)	Domingues, Reis, and Macário (2015), Bhagwat and Sharma (2007a), Shafiee, Lotfi, and Saleh (2014), Sambasivan, Nandan, and Mohamed (2009, 2009)
Warehouse capacity (4)	Guarnieri et al. (2015), Mbaga et al. (2011), Wong et al. (2014), Huang et al. (2012)
Average lateness or earliness of orders (4)	Shepherd and Günter (2011), Kim, Kumar, and Kumar (2010), Aramyan et al. (2007), Elrod, Murray, and Bande (2013)
Process efficiency (4)	Keebler and Plank (2009), Vaidya and Hudnurkar (2013), Seth, Deshmukh, and Vrat (2006), Golrizgashti (2014)
Supplier trustworthiness (4)	Hervani, Helms, and Sarkis (2005), Thakkar, Kanda, and Deshmukh (2009), Seth, Deshmukh, and Vrat (2006), Yang (2009)

applied in the reviewed research studies, more than the most-employed indicators in any of the other IC dimensions of competence, attitude, intellectual agility and renewal and development. Nevertheless, the top applied performance measures of organisational capital remain dimensions of internal processes, such as order fill rate, inventory level and condition and delivery time or speed, whereas focus on infrastructure as well as organisational culture performance is still very rare. However, there remain some infrequent measurements involved in the infrastructure of organisations that mainly concentrate on technologies (information systems, information technology and warehouse capabilities) through indicators such as level of information sharing, use of information technology, information technology and information system capability, technological capability levels, equipment utilisation/capacity, and warehouse capacity. Although performance measurement of organisational capital in logistics has been considered in several studies and models related to logistics, these studies and models primarily concentrate on internal processes and infrastructures of organisations, while culture, another major element of organisational capital, is still substantially ignored.

Discussion and future research opportunities

From the literature reviewed and the numerical results demonstrated in earlier sections, it is evident that all the examined studies mentioned or considered IC measurement, following the IC-Index from one element up to five elements. Therefore, the conclusion is that consideration of IC does exist, and has been widely examined for several years in logistics performance measurement, even though some proposed models, frameworks, and studies, such as the balanced scorecard, Skandia value scheme, and other IC measurement or classification models, did not apply or integrate the basic concepts of IC. This conforms to Al-Ali (2003), who indicated that several organisations have considered IC without even realising that they are adopting an IC approach. Nevertheless, the high level and wide range of attention on

non-financial or IC measurements in logistics-related activities have been empirically identified in several past articles (e.g. Gunasekaran and Kobu 2007; Wu and Chou 2007), and this concentration on the broad range of IC elements also still needs a proper IC-related method.

When investigating the information obtained and presented in Table 2, there is still no logistics-related study that considers all the IC sub-elements of competence, attitude, intellectual agility, relationships, renewal and development and organisation at the same time. However, when the literature was thoroughly examined by classifying the articles according to the IC-related method applied (methods that are specifically established for measuring or managing IC or intangible assets), as well as according to the type of article, interesting information was obtained, as shown in Table 7.

As presented in Table 7, most of the articles (more than 60%) focused on only one or two elements of intellectual capital management. However, when examined in more depth for the classification of reviewed studies, the articles that focused on one or two elements were generally found in articles using a non-IC-related method. Furthermore, more than 73% of these articles concentrated on only one or two elements in the measurement of IC. On the other hand, most of the other research types measured IC from three to five dimensions. Unsurprisingly, more than 55% of the review articles considered IC measurement from more than four dimensions, since review papers make a broader investigation of the measurement of IC possible. Like articles applying IC-related methods, this type of article also considers measurement of IC for up to five dimensions, but most of the research studies focused on IC measurement used three elements. Therefore, based on this information, although it is clear that IC can be managed without the application of an IC method, the level of comprehensive concentration is still mostly limited to only a few IC elements, whereas the adoption of an IC related-method could better support more comprehensive attention on several of the IC elements.

When considering the application of IC methods, the number of studies was limited, as shown in Table 8. Only three IC concepts, namely the BSC, intangible assets or resource-based view and intellectual capital, were applied in all the related articles, and all the articles studied measuring IC in logistics were entirely from the past decade. These recent developments were performed after suggestions of opportunities for improvement (Okada 2004), as well as several academic suggestions of IC's advantages for logistics (e.g. Panayides and So 2005; Tromba 2005; Wu and Lin 2005; Brah and Lim 2006; Wu 2006). These empirical suggestions could contribute to the expansion of studies on this topic. Moreover, from Table 8, it is clear, by focusing on the ICM concepts, that the BSC was the most widely adapted method in logistics performance measurement. Moreover, it is also the most frequently used IC method in logistics-related research studies to consider five elements of IC measures, even though it was previously identified for more extensive explo-

Table 7. Measurement of IC elements classified by type of article.

No. of considered IC elements	All articles	Review article	Articles with IC-related method	Articles with non-IC-related method
All IC elements	–	–	–	–
Five elements of IC	6	1	4	1
Four elements of IC	13	4	5	4
Three elements of IC	24	2	6	16
Two elements of IC	43	2	8	33
One element of IC	25	–	–	25

Table 8. Application of IC-related methods in logistics articles.

IC-related concept	No. of articles	Authors
Balanced scorecard (BSC)	15	Shaik and Abdul-Kader (2014), Bansia, Varkey, and Agrawal (2014), Bhagwat and Sharma (2007a, 2007b), Shafiee, Lotfi, and Saleh (2014), Okongwu, Brulhart, and Moncef (2015), Chia, Goh, and Hum (2009), Bigliardi and Bottani (2010), Thakkar, Kanda, and Deshmukh (2009), Najmi and Makui (2012), Bhagwat and Sharma (2009), Liang (2015), Shaik and Abdul-Kader (2013), Golrizgashti (2014)
Intangible assets or resource based view (RBV)	6	Alkhatib et al. (2015), Hwang, Chen, and Lin (2016), Sambasivan, Nandan, and Mohamed (2009), Kim, Kumar, and Kumar (2010), Karia and Wong (2013), Zailani et al. (2015)
Three traditional dimensions of IC	1	Wu and Chou (2007)
Skandia's value scheme	1	Su, Fang, and Young (2013)

ration due to its limited application in logistics-related domains (Gunasekaran and Kobu 2007). Thus, this study confirms the previously identified opportunity with the BSC and logistics; it further suggests extensive adoption of other IC methods, especially more comprehensive frameworks, such as the concept suggested by Roos and his colleagues (1997) to better enhance the competitive advantage empirically identified in past research studies (e.g. Brah and Lim 2006; Yang, Marlow, and Lu 2009).

Although there were limited applications of IC consideration in logistics measurement, application of IC-related methods could still encourage measurement of IC elements in logistics from two to five elements, while usage of non-IC-related methods or frameworks would force researchers to consider only one to five elements. Nevertheless, when most of the articles are considered, the results show that most articles applying IC-related methods examined more than three IC dimensions, whereas most articles using non-IC-related methods measured fewer than two IC elements.

Additionally, from the details presented in Table 3, it is evident that most of the studies that considered IC elements were focused only on the measurement of the organisation or relationships. The advantages from the management of these two elements could be enhanced by including other IC dimensions, since the competitive advantages delivered by other unconsidered elements, including three human capital elements and the renewal and development element, have also been empirically identified in past studies (La Londe and Ginter 2002; Chapman, Soosay, and Kandampully 2003; Sauvage 2003; Myers et al. 2004; Perng 2004; Tromba 2005; Karia and Razak 2007). Therefore, inclusion of human capital and consideration of renewal and development, as well as measurement within the logistics framework, are in great need of extensive development and application.

Although the integration of the IC-related method with the logistics concept could expand the range of IC measurement, this integrated approach may not always be necessary. This is because, as demonstrated in Table 7, it was found that even studies that did not integrate the IC-related method could also comprehensively consider and measure intangible capital compositions of up to four and five elements, like the research studies that applied IC methods within the logistics framework. However, the proportion of these studies was still quite small, and from the investigation, it was found that these research studies all aimed to propose an improved framework or to survey or measure logistics performance with a more comprehensive scope by considering new dimensions or perspectives that the traditional logistics framework had not considered before. These studies (Seth, Deshmukh, and Vrat 2006; Sha and Chen 2008; Huang et al. 2012; Dey and Cheffi 2013) considered different comprehensive concepts, including service quality, supplier service quality, sustainability, learning and growth, reverse relationships and business competitive performance.

From the information shown above, it is apparent that, although applications of the non-IC-related method seem to be able to assist the consideration or measurement of IC in logistics in up to four or five dimensions, when the proportion of the reviewed articles is considered, it can be clearly observed that the usage of IC-related methods integrated with the logistics framework could allow organisations, as well as scholars, to consider, manage, or measure the comprehensive range of elements of IC better than other approaches. From this finding and also the response to the fiercely competitive situation of logistics, which greatly requires the measurement and management of a more comprehensive range of IC elements (Wu and Chou 2007; Bhagwat and Sharma 2009), the adoption or integration of an IC-related method is suggested, and, among the various IC approaches, the recommended and existing methods which can properly deal with various IC dimensions are the BSC (Kaplan and Norton 1992), Skandia's value scheme (Edvinsson and Malone 1997), or the value description tree of IC (Roos et al. 1997).

Furthermore, another crucial improvement for logistics and IC that was incidentally found during the reviews is the opportunity to study the influence of IC elements in logistics, as well as their relative measures, on financial performance. Out of the papers reviewed, there was only one that examined this subject (Wu and Chou 2007), and it studied only the broad perspectives or major IC elements. Nevertheless, this can suggest several subsequent studies related to IC and logistics (e.g. Lee and Song 2015; Vaillancourt 2016). Therefore, studies that conduct comprehensive in-depth research on the influence of the sub-elements of IC on financial performance in logistics need a greater degree of exploration, since their results may inspire more research in this area.

As already discussed, although a review can bring out the scope and prevalence of IC measurement in the logistics domain, there is another critical and unconsidered perspective that is related to IC performance measures, and it can be examined using the results of the review depicted in Table 9.

An analysis of the IC measures, depicted in Table 9, presents several novel perspectives on logistics performance measurement, as follows:

- From the perspective of IC major capital, structural capital is the most widely applied measure. All the articles used structural capital measurement, whereas the human capital measure was applied in only 30% of the articles. This observation could imply that most logistics-related studies are still more concerned about structural capital than human capital. Therefore, from this finding, it is evident that great opportunities exist to develop or study the

Table 9. Classification of IC measures and their applications.

IC element	No. of measures	No. of applied articles	% of applied articles
Human capital	20	32	30
Competence	9	21	19
Attitude	9	20	18
Intellectual agility	2	4	4
Structural capital	138	111	100
Relationships	19	82	74
Renewal and development	7	30	27
Organisation	112	108	97

specific measurement of human capital in logistics, especially since human capital is generally empirically identified as the most important IC element (Lee and Chen 2009).

- When considering the secondary level of IC dimensions, the widely applied performance measures all involved the sub-elements of structural capital, which are organisation (97% of the articles), relationships (74% of the articles) and renewal and development (27% of the articles). In contrast, measurements of the composition of human capital were rarely adopted. Even the proportion of the highest measured sub-element (19% of the articles), competence, was lower than that of the lowest applied element of structural capital, renewal and development. At the same time, the applied level of attitude, in 18% of the articles, was quite like that of competence. Nevertheless, intellectual agility, one of the remaining IC elements under human capital, was rarely used (4% of the articles), although creativity, a component of intellectual agility, was identified as the most important aspect among human capital (Samad 2013). Therefore, from its underdevelopment and importance, intellectual capital needs more examination, development and application in logistics research.
- There are numerous IC indicators that are applied in logistics research studies, and the rankings by numbers of IC measures applied are as follows: organisation (112 measures), relationships (19 measures), competence (9 measures), attitude (9 measures), renewal and development (7 measures) and intellectual agility (2 measures). The IC element that has the highest number of measures is organisation (70% of the measures), and it also has several indicators specifically designed for logistics activity markers, such as on-time delivery rate, order fill rate, and so on. Other IC elements, namely relationships (12% of the measures), competence (6% of the measures), attitude (6% of the measures), renewal and development (4% of the measures) and intellectual agility (1% of the measures), have very small proportions. Moreover, most of the measures in these IC elements are quite generic, and they are broadly applied in other domains, such as customer satisfaction, number of new services and number of implemented suggestions. Therefore, there are several opportunities to conduct further research and develop specific measures for the undeveloped elements to better improve IC performance in logistics
- Measurement of the dimension of intellectual agility is highly underdeveloped in terms of application and development of the measure. As presented in Table 9, there were only two measures that were applied in four articles. From the literature review, it can be observed that there was no study that specifically examined the empirical advantage of intellectual agility in the domain of logistics performance; therefore, if some beneficial impacts of this IC element are demonstrated, it may stimulate and support interest, as well as study, in this area.

Conclusions

Logistics management has been empirically acknowledged as a crucial competitive advantage. Therefore, performance evaluations, as well as measures, are necessary for identifying both achievement and opportunities to improve logistics operations. In this study, academic literature related to the IC measure in logistics was reviewed and analysed. The performance indicators were carefully located, extracted and classified according to the IC-Index approach, to explore and identify opportunities for improvement in logistics measurement. In summary, the major contributions of this study include the future direction of research in this field. The contributions can be summarised as follows:

- Comprehensive consideration of IC measurement in logistics management is still substantially limited. More than 60% of reviewed studies focused on one or two components out of the six elements of IC performance. A current and crucial obstacle for organisations is to enhance competitive advantages, and for scholars, to perceive multidi-

mensional aspects of logistics management performance. Because of these issues, only traditional and rough dimensions of performance have been recognised, so firms or researchers are not supported in acknowledging and improving other important performance measures of IC elements. Generally, the traditional concepts of logistics still favour partial concentration of IC measurements. Therefore, a response to the current competitive situation of logistics is suggested, which requires a focus on the comprehensive range of IC elements and measures, applying ICM, and using measurement methods (e.g. BSC, RBV, intangible assets monitoring/management, three traditional dimensions of IC, Skandia value scheme, IC-Index, Chen's IC measurement model) with real logistics cases. Another future research area is the development or improvement of a logistics concept or framework by integrating the heterogeneous concepts of ICM and measurement specifically covering the comprehensive range of IC elements, in order to improve multidimensional consideration of the fundamentals of logistics management.

- Performance measures of two IC elements, relationships and organisation, are quite abundant regarding their direct impacts on customers, whereas the development and usage of performance measures of all three human capital components, and the renewal and development element, are very limited in the logistics domain. This finding indicates the lack of concentration, as well as gaps, in these dimensions. This lack of consideration could make organisations unable to capture the essence of organisational performance and improvement opportunities to obtain a competitive advantage. Therefore, to address this issue, further research should concentrate more on the development of performance measures for these IC elements, and the empirical exploration of their advantages to organisations. Moreover, organisations should further focus more on competitive capabilities by applying the thinking and non-thinking assets concept, which could deal with the management and measurement of these underdeveloped elements.
- Among the four elements with limited development and application, intellectual agility is the most underdeveloped and least adopted. Although the organisation's results are generally measured by a lack of performance, including external performance (relationships) and internal performance (organisation), these areas of performance are still fostered by intellectual agility as the leading performance indicator. Therefore, intellectual agility, employees' capabilities of utilising knowledge in innovating or improving internal and external services, is as crucial as other IC elements, and it affects competitive advantages and organisational achievements. Hence, to perceive and improve an organisation's competitive capability, the development of performance measures of intellectual agility should be considered. Moreover, to encourage the practical management and measurement of this IC element, further academic research in logistics that empirically validates and demonstrates the impact of intellectual agility on other IC elements and other critical organisational performance areas is absolutely required.
- There was only one empirical study with limited objectives that examined the positive influence of three rough IC elements on the ultimate financial performance in logistics. It is apparent that the empirical findings on this issue are critically rare, so this is still weak evidence to convince practitioners and researchers to extensively develop and focus on this aspect. Furthermore, there is still no study that demonstrates clear evidence related to the performance of the six elements of IC as affecting organisational performance and achievement of goals. Therefore, another research opportunity is to empirically investigate the influence of each IC element and its measure on other IC elements, IC measures, and financial performance. Moreover, whenever there is strong and sufficient evidence of these influences, another future direction for development is the creation of an IC strategy map for logistics management, demonstrating the relationships among IC measures or even financial measures, which can be practically applied as ICM and measurement guidelines for organisations.
- Most of the measures of the IC elements in logistics, except the element of organisation, are generic indicators that could be found in other research areas. This kind of generic purpose leads to the measurement of the overall aspect of performance, which makes it difficult to capture or reflect the essence of IC performance in logistics management. Because of this issue, a practitioner or researcher cannot perceive the performance of a specific activity, service, or process, so it is quite difficult to detect a particular problem, identify a more precise improvement opportunity, or develop and select a proper tool or method for solving or mitigating problems. Therefore, to more precisely determine areas of improvement that will directly affect the performance of logistics, further research should deal with the development of more specific measures for the previously undeveloped IC dimensions, including competence, attitude, intellectual agility, relationships, and renewal and development. However, this suggested development may lead to an abundant number of measures, similar to the current situation of organisational capital. Hence, to efficiently utilise limited resources of firms, the impact and priority of measures related to organisations' goals and strategies should also be further studied.

These points highlight the gaps in the literature, and opportunities for improving and conducting future research on IC and performance measurement for logistics. These opportunities for improvement are expected to support researchers

and practitioners in their future development of research or practice. Moreover, the obtained performance measures, their classifications and citations can be further applied as references, and a foundation for developing IC-integrated management and measurement concepts and models either for logistics or other broad and narrow concepts, such as supply chain management, production management and production systems. Nevertheless, it should be noted that these results have some limitations, such as inclusion of only available articles, academic database accessibility and combined keywords. All the articles were obtained from four major academic databases using a combination of eight keywords, so the limitations of database availability and keyword search might have failed to identify some related articles.

Acknowledgements

The authors are thankful to the Office of the Higher Education Commission (OHEC) and Thailand Research Fund (TRF) for providing the research grant for new scholars (contract number: MRG5980023)in support of this study. Moreover, the authors are also sincerely grateful to all anonymous reviewers and an associate editor for their valuable comments that supported the constructive development to this paper.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Office of the Higher Education Commission (OHEC) and Thailand Research Fund (TRF) [contract number: MRG5980023].

ORCID

Ratapol Wudhikarn http://orcid.org/0000-0003-1907-9444
Gilles Neubert http://orcid.org/0000-0001-5816-2000

References

Abrahamsson, M., and H. Aronsson. 1999. "Measuring Logistics Structure." *International Journal of Logistics Research and Applications* 2: 263–284.

Agrawal, S., R. K. Singh, and Q. Murtaza. 2015. "A Literature Review and Perspectives in Reverse Logistics." *Resources, Conservation and Recycling* 97: 76–92.

Aguezzoul, A. 2014. "Third-party Logistics Selection Problem: A Literature Review on Criteria and Methods." *Omega* 49: 69–78.

Akyuz, G. A., and T. E. Erkan. 2010. "Supply Chain Performance Measurement: A Literature Review." *International Journal of Production Research* 48: 5137–5155.

Al-Ali, N. 2003. *Comprehensive Intellectual Capital Management: Step-by-step*. New Jersey: John Wiley & Sons.

Alkhatib, S. F., R. Darlington, Z. Yang, and T. T. Nguyen. 2015. "A Novel Technique for Evaluating and Selecting Logistics Service Providers Based on the Logistics Resource View." *Expert Systems with Applications* 42: 6976–6989.

Anand, N., and N. Grover. 2015. "Measuring Retail Supply Chain Performance: Theoretical Model Using Key Performance Indicators (KPIs)." *Benchmarking: An International Journal* 22: 135–166.

Anderson, E. W., C. Fornell, and D. R. Lehmann. 1994. "Customer Satisfaction, Market Share, and Profitability: Findings from Sweden." *Journal of Marketing* 58: 53–66.

Aramyan, L. H., A. G. J. M. O. Lansink, J. G. A. J. van der Vorst, and O. van Kooten. 2007. "Performance Measurement in Agri-food Supply Chains: A Case Study." *Supply Chain Management: An International Journal* 12: 304–315.

Aribi, A., and O. Dupouët. 2015. "The Role of Organizational and Social Capital in the Firm's Absorptive Capacity." *Journal of Knowledge Management* 19: 987–1006.

Arlbjørn, J. S., and T. Lüthje. 2012. "Global Operations and Their Interaction with Supply Chain Performance." *Industrial Management and Data Systems* 112: 1044–1064.

Bai, C., and J. Sarkis. 2012. "Supply-chain Performance-measurement System Management Using Neighbourhood Rough Sets." *International Journal of Production Research* 50: 2484–2500.

Bai, C., and J. Sarkis. 2014. "Determining and Applying Sustainable Supplier Key Performance Indicators." *Supply Chain Management: An International Journal* 19: 275–291.

Bai, C., J. Sarkis, X. Wei, and L. Koh. 2012. "Evaluating Ecological Sustainable Performance Measures for Supply Chain Management." *Supply Chain Management: An International Journal* 17: 78–92.

Banomyong, R., and N. Supatn. 2011. "Developing a Supply Chain Performance Tool for SMEs in Thailand." *Supply Chain Management: An International Journal* 16: 20–31.
Bansia, M., J. K. Varkey, and S. Agrawal. 2014. "Development of a Reverse Logistics Performance Measurement System for a Battery Manufacturer." *Procedia Materials Science* 6: 1419–1427.
Barbosa, D. H., and M. A. Musetti. 2011. "The Use of Performance Measurement System in Logistics Change Process." *International Journal of Productivity and Performance Management* 60: 339–359.
Barney, J. 1991. "Firm Resources and Sustained Competitive Advantage." *Journal of Management* 17: 99–120.
Basu, R. 2001. "New Criteria of Performance Management: A Transition from Enterprise to Collaborative Supply Chain." *Measuring Business Excellence* 5: 7–12.
Beamon, B. M. 1999. "Measuring Supply Chain Performance." *International Journal of Operations and Production Management* 19: 275–292.
Becker, B. E., M. A. Huselid, and D. Ulrich. 2001. *The HR Scorecard*. Boston, MA: Harvard Business Scholl Press.
Bhagwat, R., and M. K. Sharma. 2007a. "Performance Measurement of Supply Chain Management: A Balanced Scorecard Approach." *Computers and Industrial Engineering* 53: 43–62.
Bhagwat, R., and M. K. Sharma. 2007b. "Performance Measurement of Supply Chain Management using the Analytical Hierarchy Process." *Production Planning and Control* 18: 666–680.
Bhagwat, R., and M. K. Sharma. 2009. "An Application of the Integrated AHP-PGP Model for Performance Measurement of Supply Chain Management." *Production Planning and Control* 20: 678–690.
Bigliardi, B., and E. Bottani. 2010. "Performance Measurement in the Food Supply Chain: A Balanced Scorecard Approach." *Facilities* 28: 249–260.
Bititici, U. S., S. Cavalieri, and G. Cieminski. 2005. "Implementation of Performance Measurement Systems: Private and Public Sectors Editorial." *Production Planning and Control* 16: 99–100.
Blome, C., T. Schoenherr, and D. Rexhausen. 2013. "Antecedents and Enablers of Supply Chain Agility and Its Effect on Performance: A Dynamic Capabilities Perspective." *International Journal of Production Research* 51: 1295–1318.
Bontis, N. 1997. *Intellectual Capital Questionnaire*. Hamilton: Institute for Intellectual Capital Research.
Bontis, N. 2001. "CKO Wanted ? Evangelical Skills Necessary: A Review of the Chief Knowledge Officer Position." *Knowledge and Process Management* 8: 29–38.
Bontis, N., M. M. Crossan, and J. Hulland. 2002. "Managing an Organizational Learning System by Aligning Stocks and Flows." *Journal of Management Studies* 39: 437–469.
Bozbura, F. T., A. Beskese, and C. Kahraman. 2007. "Prioritization of Human Capital Measurement Indicators Using Fuzzy AHP." *Expert Systems with Applications* 32: 1100–1112.
Brah, S. A., and H. Y. Lim. 2006. "The Effects of Technology and TQM on the Performance of Logistics Companies." *International Journal of Physical Distribution and Logistics Management* 36: 192–209.
Brooks, M. R. 1999. "Performance Evaluation of Carriers by North American Logistics Service Firms." *Transport Reviews* 19: 273–283.
Brusoni, S., A. Prencipe, and K. Pavitt. 2001. "Knowledge Specialization, Organizational Coupling, and the Boundaries of the Firm: Why Do Firms Know More than They Make?" *Administrative Science Quarterly* 46: 597–621.
Cai, J., X. Liu, Z. Xiao, and J. Liu. 2009. "Improving Supply Chain Performance Management: A Systematic Approach to Analyzing Iterative KPI Accomplishment." *Decision Support Systems* 46: 512–521.
Caplice, C., and Y. Sheffi. 1995. "A Review and Evaluation of Logistics Performance Measurement Systems." *The International Journal of Logistics Management* 6: 61–74.
Chae, B. 2009. "Developing Key Performance Indicators for Supply Chain: An Industry Perspective." *Supply Chain Management: An International Journal* 14: 422–428.
Chan, F. T. S. 2003. "Performance Measurement in a Supply Chain." *The International Journal of Advanced Manufacturing Technology* 21: 534–548.
Chan, F. T. S., H. J. Qi, H. K. Chan, H. C. W. Lau, and R. W. L. Ip. 2003. "A Conceptual Model of Performance Measurement for Supply Chains." *Management Decision* 41: 635–642.
Chapman, R. L., C. Soosay, and J. Kandampully. 2003. "Innovation in Logistic Services and the New Business Model: A Conceptual Framework." *International Journal of Physical Distribution and Logistics Management* 33: 630–650.
Chen, M. C., S. J. Cheng, and Y. Hwang. 2005. "An Empirical Investigation of the Relationship between Intellectual Capital and Firms' Market Value and Financial Performance." *Journal of Intellectual Capital* 6: 159–176.
Chen, J., Z. Zhu, and H. Y. Xie. 2004. "Measuring Intellectual Capital: A New Model and Empirical Study." *Journal of Intellectual Capital* 5: 195–212.
Chia, A., M. Goh, and S. H. Hum. 2009. "Performance Measurement in Supply Chain Entities: Balanced Scorecard Perspective." *Benchmarking: An International Journal* 16: 605–620.
Chiu, H. N. 1995. "The Integrated Logistics Management System: A Framework and Case Study." *International Journal of Physical Distribution & Logistics Management* 25: 4–22.
Choong, K. K. 2008. "Intellectual Capital: Definitions, Categorization and Reporting Models." *Journal of Intellectual Capital* 9: 609–638.

Choong, K. K. 2013. "Understanding the Features of Performance Measurement System: A Literature Review." *Measuring Business Excellence* 17: 102–121.
Chow, G., T. D. Heaver, and L. E. Henriksson. 1994. "Logistics Performance: Definition and Measurement." *International Journal of Physical Distribution and Logistics Management* 24: 17–28.
CMA (Canadian Management Accountants). 1999. *Focus Group Draft: Measuring Knowledge Assets*. Mississauga: CMA.
Cuthbertson, R., and W. Piotrowicz. 2011. "Performance Measurement Systems in Supply Chains: A Framework for Contextual Analysis." *International Journal of Productivity and Performance Management* 60: 583–602.
Daugherty, P. J., T. P. Stank, and A. E. Ellinger. 1998. "Leveraging Logistics/Distribution Capabilities: The Impact of Logistics Service on Market Share." *Journal of Business Logistics* 19: 35–51.
Davis-Sramek, B., J. T. Mentzer, and T. P. Stank. 2008. "Creating Consumer Durable Retailer Customer Loyalty through Order Fulfillment Service Operations." *Journal of Operations Management* 26: 781–797.
Dey, P. K., and W. Cheffi. 2013. "Green Supply Chain Performance Measurement Using the Analytic Hierarchy Process: A Comparative Analysis of Manufacturing Organisations." *Production Planning and Control* 24: 702–720.
Domingues, M. L., V. Reis, and R. Macário. 2015. "A Comprehensive Framework for Measuring Performance in a Third-party Logistics Provider." *Transportation Research Procedia* 10: 662–672.
Edvinsson, L., and M. S. Malone. 1997. *Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower*. New York: Harper Business.
Edvinsson, L., and P. Sullivan. 1996. "Developing a Model for Managing Intellectual Capital." *European Management Journal* 14: 356–364.
El-Bannany, M. 2011. "Earning Quality and Other Factors Affecting Intellectual Capital Performance in Banks: The UAE Case." *Proceedings of the 3rd European Conference on Intellectual Capital*, April 18–19, 136–146. Cyprus: Academic Publishing International.
Elrod, C., S. Murray, and S. Bande. 2013. "A Review of Performance Metrics for Supply Chain Management." *Engineering Management Journal* 25: 39–50.
Evenson, R. E., and L. E. Westphal. 1995. "Technological Change and Technological Strategy." In *Handbook of Development Economics*, edited by J. Behrman and T. N. Srinivasan, Vol. 3A, 2209–2299. Amsterdam: North-Holland.
Fawcett, S. E., and M. B. Cooper. 1998. "Logistics Performance Measurement and Customer Success." *Industrial Marketing Management* 27: 341–357.
Fugate, B. S., J. T. Mentzer, and T. P. Stank. 2010. "Logistics Performance: Efficiency, Effectiveness, and Differentiation." *Journal of Business Logistics* 31: 43–62.
Garcia, F. A., M. G. Marchetta, M. Camargo, L. Morel, and R. Q. Forradellas. 2012. "A Framework for Measuring Logistics Performance in the Wine Industry." *International Journal of Production Economics* 135: 284–298.
Giovanis, A. N., P. Tomaras, and D. Zondiros. 2013. "Suppliers Logistics Service Quality Performance and Its Effect on Retailers' Behavioral Intentions." *Procedia – Social and Behavioral Sciences* 73: 302–309.
Gogan, L. M., D. C. Duran, and A. Draghici. 2015. "Structural Capital - a Proposed Measurement Model." *Procedia Economics and Finance* 23: 1139–1146.
Golrizgashti, S. 2014. "Supply Chain Value Creation Methodology under BSC Approach." *Journal of Industrial Engineering International* 10: 67(1)–67(15).
Green Jr, K. W., D. Whitten, and R. A. Inman. 2008. "The Impact of Logistics Performance on Organizational Performance in a Supply Chain Context." *Supply Chain Management: An International Journal* 13: 317–327.
Griffis, S. E., T. J. Goldsby, M. Cooper, and D. J. Closs. 2007. "Aligning Logistics Performance Measures to the Information Needs of the Firm." *Journal of Business Logistics* 28: 35–56.
Guarnieri, P., V. A. Sobreiro, M. S. Nagano, and A. L. M. Serrano. 2015. "The Challenge of Selecting and Evaluating Third-party Reverse Logistics Providers in a Multicriteria Perspective: A Brazilian Case." *Journal of Cleaner Production* 96: 209–219.
Gulledge, T., and T. Chavusholu. 2008. "Automating the Construction of Supply Chain Key Performance Indicators." *Industrial Management and Data Systems* 108: 750–774.
Gunasekaran, A., and B. Kobu. 2007. "Performance Measures and Metrics in Logistics and Supply Chain Management: A Review of Recent Literature (1995–2004) for Research and Applications." *International Journal of Production Research* 45: 2819–2840.
Gunasekaran, A., and E. W. Ngai. 2003. "The Successful Management of a Small Logistics Company." *International Journal of Physical Distribution and Logistics Management* 33: 825–842.
Gunasekaran, A., C. Patel, and R. E. McGaughey. 2004. "A Framework for Supply Chain Performance Measurement." *International Journal of Production Economics* 87: 333–347.
Hansen, M. T., N. Nohria, and T. Tierney. 1999. "What's Your Strategy for Managing Knowledge?" *Harvard Business Review* 77: 106–116.
Harland, C. M., R. C. Lamming, H. Walker, W. E. Phillips, N. D. Caldwell, and T. E. Johnsen. 2006. "Supply Management: Is It a Discipline?" *International Journal of Operations & Production Management* 26: 730–753.
Hervani, A. A., M. M. Helms, and J. Sarkis. 2005. "Performance Measurement for Green Supply Chain Management." *Benchmarking: An International Journal* 12: 330–353.

Hofmann, E., and A. Locker. 2009. "Value-based Performance Measurement in Supply Chains: A Case Study from the Packaging Industry." *Production Planning and Control* 20: 68–81.
Holmberg, S. 2000. "A Systems Perspective on Supply Chain Measurements." *International Journal of Physical Distribution and Logistics Management* 30: 847–868.
Hsu, Y. H., and W. Fang. 2008. "Intellectual Capital and New Product Development Performance: The Mediating Role of Organizational Learning Capability." *Technological Forecasting and Social Change* 76: 664–677.
Huang, C. J., and K. P. Huang. 2012. "The Logistics Capabilities Scale for Logistics Service Providers." *Journal of Information and Optimization Sciences* 33: 135–148.
Huang, R. H., C. L. Yang, C. C. Lin, and Y. J. Cheng. 2012. "Performance Evaluation Model for Reverse Logistics – The Case of Recycled Computers." *Journal of Statistics and Management Systems* 15: 323–343.
Hunt, S. D. 2000. *A General Theory of Competition: Resource, Competences, Productivity, Economic Growth*. Thousand Oaks, CA: Sage.
Hwang, B. N., T. T. Chen, and J. T. Lin. 2016. "3PL Selection Criteria in Integrated Circuit Manufacturing Industry in Taiwan." *Supply Chain Management: An International Journal* 21: 103–124.
Innis, D. E., and B. J. La Londe. 1994. "Customer Service: The Key to Customer Satisfaction, Customer Loyalty, and Market Share." *Journal of Business Logistics* 15: 1–27.
Jakhar, S. K. 2014. "Designing the Green Supply Chain Performance Optimisation Model." *Global Journal of Flexible Systems Management* 15: 235–259.
Jakhar, S. K. 2015. "Performance Evaluation and a Flow Allocation Decision Model for a Sustainable Supply Chain of an Apparel Industry." *Journal of Cleaner Production* 87: 391–413.
Jeenanunta, C., Y. Ueki, and T. Visanvetchakij. 2013. "Supply Chain Collaboration and Firm Performance in Thai Automotive and Electronics Industries." *Global Business Perspectives* 1: 418–432.
Jothimani, D., and S. P. Sarmah. 2014. "Supply Chain Performance Measurement for Third Party Logistics." *Benchmarking: An International Journal* 21: 944–963.
Julnes, P. 2007. *Performance Measurement*. Boca Raton, FL: CRC Press.
Junell, J., and P. Ståhle. 2011. "Measuring Organizational Renewal Capability: Case Training Service Business." *Competitiveness Review: An International Business Journal* 21: 247–268.
Kale, S. 2009. "Fuzzy Intellectual Capital Index for Construction Firms." *Journal of Construction Engineering and Management* 135: 508–517.
Kaplan, R. S., and D. P. Norton. 1992. "The Balanced Scorecard: Measures That Drive Performance." *Harvard Business Review* 70: 71–79.
Karami, S., and A. Vafaei. 2011. "Australian Universities and Intellectual Capital Reporting: Case Study of the Group of Eight." *Proceedings of 9th International Conference on Intellectual Capital, Knowledge Management and Organisational Learning*, 18–19 October, 120–127. Colombia, Reading: Academic Publishing International Limited.
Karia, N., and R. C. Razak. 2007. "Logistics Assets That Payoff Competitive Advantage." In *Information Management in the Networked Economy: Issues & Solutions*, edited by K. S. Soliman, 33–39. New York: International Business Information Management Association.
Karia, N., and C. Y. Wong. 2013. "The Impact of Logistics Resources on the Performance of Malaysian Logistics Service Providers." *Production Planning and Control* 24: 589–606.
Keebler, J. S., and R. E. Plank. 2009. "Logistics Performance Measurement in the Supply Chain: A Benchmark." *Benchmarking: An International Journal* 16: 785–798.
Kilibarda, M., S. Zečević, and M. Vidović. 2012. "Measuring the Quality of Logistic Service as an Element of the Logistics Provider Of0fering." *Total Quality Management and Business Excellence* 23: 1345–1361.
Kim, D. Y., V. Kumar, and U. Kumar. 2010. "Performance Assessment Framework for Supply Chain Partnership." *Supply Chain Management: An International Journal* 15: 187–195.
Koçoğlu, İ., S. Z., Manoğlu, and H. İnce. 2009. "The Relationship between Firm Intellectual Capital and the Competitive Advantage." *Journal of Global Strategic Management* 6: 181–208.
Kocaoğlu, B., B. Gülsün, and M. Tanyaş. 2013. "A SCOR Based Approach for Measuring a Benchmarkable Supply Chain Performance." *Journal of Intelligent Manufacturing* 24: 113–132.
Kovács, G., K. M. Spens, and D. B. Vellenga. 2008. "Academic Publishing in the Nordic Countries – A Survey of Logistics and Supply Chain Related Journal Rankings." *International Journal of Logistics Research and Applications* 11: 313–329.
Krakovics, F., J. E. Leal, P. Mendes Jr., and R. L. Santos. 2008. "Defining and Calibrating Performance Indicators of a 4PL in the Chemical Industry in Brazil." *International Journal of Production Economics* 115: 502–514.
Kucukaltan, B., Z. Irani, and E. Aktas. 2016. "A Decision Support Model for Identification and Prioritization of Key Performance Indicators in the Logistics Industry." *Computers in Human Behavior* 65: 346–358.
Kunadhamraks, P., and S. Hanaoka. 2008. "Evaluating the Logistics Performance of Intermodal Transportation in Thailand." *Asia Pacific Journal of Marketing and Logistics* 20: 323–342.
La Londe, B. J., and J. L. Ginter, eds. 2002. *The Ohio State University 2002 Survey of Career Patterns in Logistics*. Columbus, GA: The Ohio State University.

Lai, K. H., and T. C. E. Cheng. 2003. "Supply Chain Performance in Transport Logistics: An Assessment by Service Providers." *International Journal of Logistics Research and Applications* 6: 151–164.
Lai, F., D. Li, Q. Wang, and X. Zhao. 2008. "The Information Technology Capability of Third-party Logistics Providers: A Resource-based View and Empirical Evidence from China." *Journal of Supply Chain Management* 44: 22–38.
Lai, K. H., E. W. T. Ngai, and T. C. E. Cheng. 2002. "Measures for Evaluating Supply Chain Performance in Transport Logistics." *Transportation Research Part E: Logistics and Transportation Review* 38: 439–456.
Lambert, D. M., and R. Burduroglo. 2000. "Measuring and Selling the Value of Logistics." *The International Journal of Logistics Management* 11: 1–16.
Lambert, D. M., and J. R. Stock. 1993. *Strategic Logistics Management*. Homewood: Richard D. Irwin.
Lambert, D. M., J. R. Stock, and L. Elram. 1998. *Fundamentals of Logistics Management*. International ed. Singapore: McGraw Hill.
Lau, K. H. 2011. "Benchmarking Green Logistics Performance with a Composite Index." *Benchmarking: An International Journal* 18: 873–896.
Lee, S. H., and C. Y. Chen. 2009. "Developing a Hierarchical Structure for Assessing Cooperative Education Programs." *Asia-Pacific Journal of Cooperative Education* 10: 57–64.
Lee, E. S., and D. W. Song. 2015. "The Effect of Shipping Knowledge and Absorptive Capacity on Organizational Innovation and Logistics Value." *The International Journal of Logistics Management* 26: 218–237.
Leuthesser, L., and A. K. Kohli. 1995. "Relational Behavior in Business Markets." *Journal of Business Research* 34: 9–20.
Li, X., Q. Wu, and C. W. Holsapple. 2015. "Best-value Supply Chains and Firms' Competitive Performance: Empirical Studies of Their Linkage." *International Journal of Operations and Production Management* 35: 1688–1709.
Liang, Y. H. 2015. "Performance Measurement of Interorganizational Information Systems in the Supply Chain." *International Journal of Production Research* 53: 5484–5499.
Lin, C. Y. 2007. "Supply Chain Performance and the Adoption of New Logistics Technologies for Logistics Service Providers in Taiwan." *Journal of Statistics and Management Systems* 10: 519–543.
Lu, C. S., and C. C. Yang. 2010. "Logistics Service Capabilities and Firm Performance of International Distribution Center Operators." *The Service Industries Journal* 30: 281–298.
Luthy, D. H. 1998. "Intellectual Capital and Its Measurement." Accessed 29 September 2017. http://www3.bus.osaka-cu. ac.jp/apira98/archives/htmls/25.htm
Lynch, D. F., S. B. Keller, and J. Ozment. 2000. "The Effects of Logistics Capabilities and Strategy on Firm Performance." *Journal of Business Logistics* 21: 47–68.
Marr, B., and J. Chatzkel. 2004. "Intellectual Capital at the Crossroads: Managing, Measuring, and Reporting of IC." *Journal of Intellectual Capital* 5: 224–229.
Maskell, B. 1989. "Performance Measures of World Class Manufacturing." *Management Accounting* 67: 32–33.
Mayring, P. 2008. *Qualitative Inhaltanalyse-Grundlagen und Techniken* [Qualitative Content Analysis]. Weinheim: Beltz Verlag.
Mbaga, M., M. S. R. Al-Shabibi, H. Boughanmi, and S. M. Zekri. 2011. "A Comparative Study of Dates Export Supply Chain Performance: The Case of Oman and Tunisia." *Benchmarking: An International Journal* 18: 386–408.
Mentzer, J. T., and L. R. Williams. 2001. "The Role of Logistics Leverage in Marketing Strategy." *Journal of Marketing Channels* 8: 29–47.
Meredith, J. 1993. "Theory Building through Conceptual Methods." *International Journal of Operation and Production Management* 13: 3–11.
Mishra, P., and R. K. Sharma. 2014. "Benchmarking SCM Performance and Empirical Analysis: A Case from Paint Industry." *Logistics Research* 7: 1–16.
Moreira, M., and B. Tjahjono. 2016. "Applying Performance Measures to Support Decision-making in Supply Chain Operations: A Case of Beverage Industry." *International Journal of Production Research* 54: 2345–2365.
Morgan, C. 2004. "Structure, Speed and Salience: Performance Measurement in the Supply Chain." *Business Process Management Journal* 10: 522–536.
Mothilal, S., A. Gunasekaran, S. P. Nachiappan, and J. Jayaram. 2012. "Key Success Factors and Their Performance Implications in the Indian Third-party Logistics (3PL) Industry." *International Journal of Production Research* 50: 2407–2422.
Myers, M. B., D. A. Griffith, P. J. Daugherty, and R. F. Lusch. 2004. "Maximizing the Human Capital Equation in Logistics: Education, Experience, and Skills." *Journal of Business Logistics* 25: 211–232.
Najmi, A., and A. Makui. 2012. "A Conceptual Model for Measuring Supply Chain's Performance." *Production Planning and Control* 23: 694–706.
Neely, A., M. Gregory, and K. Platts. 1995. "Performance Measurement System Design." *International Journal of Operations and Production Management* 15: 80–116.
Nickerson, J. A., and B. S. Silverman. 1997. "Intellectual Capital Management Strategy: The Foundation of Successful New Business Generation." *Journal of Knowledge Management* 1: 320–331.
Okada, E. 2004. "Intellectual Capital Potential Survey." *NIKKE* I: 6.
Okongwu, U., F. Brulhart, and B. Moncef. 2015. "Causal Linkages between Supply Chain Management Practices and Performance: A Balanced Scorecard Strategy Map Perspective." *Journal of Manufacturing Technology Management* 26: 678–702.

Olavarrieta, S., and A. E. Ellinger. 1997. "Resource-based Theory and Strategic Logistics Research." *International Journal of Physical Distribution and Logistics Management* 279: 559–587.

Ordóñez de Pablos, P. 2005. "Intellectual Capital Reports in India: Lessons from a Case Study." *Journal of Intellectual Capital* 6: 141–149.

Panayides, P. M. 2004. "Logistics Service Providers: An Empirical Study of Marketing Strategies and Company Performance." *International Journal of Logistics Research and Applications* 7: 1–15.

Panayides, P. M. 2007. "The Impact of Organizational Learning on Relationship Orientation, Logistics Service Effectiveness and Performance." *Industrial Marketing Management* 36: 68–80.

Panayides, P. M., and M. So. 2005. "The Impact of Integrated Logistics Relationships on Third-party Logistics Service Quality and Performance." *Maritime Economics and Logistics* 7: 36–55.

Papakiriakopoulos, D., and K. Pramatari. 2010. "Collaborative Performance Measurement in Supply Chain." *Industrial Management and Data Systems* 110: 1297–1318.

Perng, D. B., ed. 2004. *The Impact of Knowledge and Economy on Logistics, in Commerce*. Hsinchu: Taiwan Logistics Yearbook, Ministry of Economic Affairs.

Petrash, G. 1996. "Dow's Journey to a Knowledge Value Management Culture." *European Management Journal* 14: 365–373.

Petty, P., and J. Guthrie. 2000. "Intellectual Capital Literature Review: Measurement, Reporting and Management." *Journal of Intellectual Capital* 1: 155–175.

Piecyk, M. I., and M. Björklund. 2015. "Logistics Service Providers and Corporate Social Responsibility: Sustainability Reporting in the Logistics Industry." *International Journal of Physical Distribution and Logistics Management* 45: 459–485.

Pöyhönen, A.. 2004. "Modelling and Measuring Organizational Renewal Capability." PhD diss., Lappeenranta University of Technology.

Raghavan, R. 2011. *Human Capital Management Challenges in India*. Oxford: Chandos.

Ramanathan, R. 2010. "The Moderating Roles of Risk and Efficiency on the Relationship between Logistics Performance and Customer Loyalty in e-commerce." *Transportation Research Part E: Logistics and Transportation Review* 46: 950–962.

Ramanathan, U., A. Gunasekaran, and N. Subramanian. 2011. "Supply Chain Collaboration Performance Metrics: A Conceptual Framework." *Benchmarking: An International Journal* 18: 856–872.

Ramos, M. M. 2004. "Change in the Logistics Management Style through Performance Indicators: A Case Study." *International Journal of Logistics Research and Applications* 7: 313–324.

Reiner, G., and P. Hofmann. 2006. "Efficiency Analysis of Supply Chain Processes." *International Journal of Production Research* 44: 5065–5087.

Roos, G., and J. Roos. 1998. *Intellectual Capital*. New York: New York University Press.

Roos, J., G. Roos, N. C. Dragonett, and L. Edvinsson. 1997. *Intellectual Capital: Navigating the New Business Landscape*. 1st ed. New York: New York University Press.

Saad, M., and B. Patel. 2006. "An Investigation of Supply Chain Performance Measurement in the Indian Automotive Sector." *Benchmarking: An International Journal* 13: 36–53.

Samad, S. 2013. "Assessing the Contribution of Human Capital on Business Performance." *International Journal of Trade, Economics and Finance* 4: 393–397.

Sambasivan, M., T. Nandan, and Z. A. Mohamed. 2009. "Consolidation of Performance Measures in a Supply Chain Environment." *Journal of Enterprise Information Management* 22: 660–689.

Sauvage, T. 2003. "The Relationship between Technology and Logistics Third-party Providers." *International Journal of Physical Distribution and Logistics Management* 33: 236–253.

Schramm-Klein, H., and D. Morschett. 2006. "The Relationship between Marketing Performance, Logistics Performance and Company Performance for Retail Companies." *The International Review of Retail, Distribution and Consumer Research* 16: 277–296.

Sellitto, M. A., G. M. Pereira, M. Borchardt, R. I. da Silva, and C. V. Viegas. 2015. "A SCOR-based Model for Supply Chain Performance Measurement: Application in the Footwear Industry." *International Journal of Production Research* 53: 4917–4926.

Seth, N., S. G. Deshmukh, and P. Vrat. 2006. "SSQSC: A Tool to Measure Supplier Service Quality in Supply Chain." *Production Planning and Control* 17: 448–463.

Sha, D. Y., and P. K. Chen. 2008. "Measuring the Performance of Different Supply-chain Integration Strategies." *Journal of Statistics and Management Systems* 11: 721–748.

Shafiee, M., F. H. Lotfi, and H. Saleh. 2014. "Supply Chain Performance Evaluation with Data Envelopment Analysis and Balanced Scorecard Approach." *Applied Mathematical Modelling* 38: 5092–5112.

Shaik, M., and W. Abdul-Kader. 2012. "Performance Measurement of Reverse Logistics Enterprise: A Comprehensive and Integrated Approach." *Measuring Business Excellence* 16: 23–34.

Shaik, M. N., and W. Abdul-Kader. 2013. "Transportation in Reverse Logistics Enterprise: A Comprehensive Performance Measurement Methodology." *Production Planning and Control* 24: 495–510.

Shaik, M. N., and W. Abdul-Kader. 2014. "Comprehensive Performance Measurement and Causal-effect Decision Making Model for Reverse Logistics Enterprise." *Computers and Industrial Engineering* 68: 87–103.

Shang, K. C., and P. B. Marlow. 2005. "Logistics Capability and Performance in Taiwan's Major Manufacturing Firms." *Transportation Research Part E: Logistics and Transportation Review* 41: 217–234.
Sharma, A., D. Grewal, and M. Levy. 1995. "The Customer Satisfaction/Logistics Interface." *Journal of Business Logistics* 16: 1–21.
Shen, C. E., and C. C. Chou. 2010. "Business Process Re-engineering in the Logistics Industry: A Study of Implementation, Success Factors, and Performance." *Enterprise Information Systems* 4: 61–78.
Shepherd, C., and H. Günter. 2011. "Measuring Supply Chain Performance: Current Research and Future Directions." *Behavioral Operations in Planning and Scheduling* Part II: 105–121.
Solakivi, T., J. Töyli, J. Engblom, and L. Ojala. 2011. "Logistics Outsourcing and Company Performance of SMEs: Evidence from 223 Firms Operating in Finland." *Strategic Outsourcing: An International Journal* 4: 131–151.
Solitander, M., and A. Tidström. 2010. "Competitive Flows of Intellectual Capital in Value Creating Networks." *Journal of Intellectual Capital* 11: 23–38.
Soni, G., and R. Kodali. 2010. "Internal Benchmarking for Assessment of Supply Chain Performance." *Benchmarking: An International Journal* 17: 44–76.
Stank, T. P., T. J. Goldsby, S. K. Vickery, and K. Savitskie. 2003. "Logistics Service Performance: Estimating Its Influence on Market Share." *Journal of Business Logistics* 24: 27–55.
Staudt, F. H., G. Alpan, M. Di Mascolo, and C. M. T. Rodriguez. 2015. "Warehouse Performance Measurement: A Literature Review." *International Journal of Production Research* 53: 5524–5544.
Stewart, T. A. 1997. *Intellectual Capital: The New Wealth of Organizations*. London: Nicholas Brealey.
Su, H. Y., S. C. Fang, and C. S. Young. 2013. "Influences of Relationship Transparency from Intellectual Capital Reporting on Supply Chain Partnerships with Suppliers: A Field Experiment." *Supply Chain Management: An International Journal* 18: 178–193.
Sveiby, K. E. 1997. *The New Organizational Wealth-managing and Measuring Knowledge-based Assets*. 1st ed. San Francisco, CA: Berrett-Koehler.
Teece, D. J., G. Pisano, and A. Shuen. 1997. "Dynamic Capabilities and Strategic Management." *Strategic Management Journal* 18: 509–533.
Thakkar, J., A. Kanda, and S. G. Deshmukh. 2009. "Supply Chain Performance Measurement Framework for Small and Medium Scale Enterprises." *Benchmarking: An International Journal* 16: 702–723.
Thunberg, M., and F. Persson. 2014. "Using the SCOR Model's Performance Measurements to Improve Construction Logistics." *Production Planning and Control* 25: 1065–1078.
Tromba, L. 2005. "How to Position Yourself for Success in a Supply Chain Leadership Role." *CSCMP Supply Chain Comment* 39: 18–20.
Turi, A., G. Goncalves, and M. Mocan. 2014. "Challenges and Competitiveness Indicators for the Sustainable Development of the Supply Chain in Food Industry." *Procedia – Social and Behavioral Sciences* 124: 133–141.
Tushman, M. L., and L. Rosenkopf. 1992. "On the Organizational Determinants of Technological Change: Toward a Sociology of Technological Evolution." In *Research in Organizational Behavior*, edited by B. Staw and L. Cummings, 311–347. Greenwich: Jai Press.
Vaidya, O., and M. Hudnurkar. 2013. "Multi-criteria Supply Chain Performance Evaluation: An Indian Chemical Industry Case Study." *International Journal of Productivity and Performance Management* 62: 293–316.
Vaillancourt, A. 2016. "A Theoretical Framework for Consolidation in Humanitarian Logistics." *Journal of Humanitarian Logistics and Supply Chain Management* 6: 2–23.
Van Hoek, R. I., R. Chatham, and R. Wilding. 2002. "Managers in Supply Chain Management, the Critical Dimension." *Supply Chain Management: An International Journal* 7: 119–125.
Varsei, M., C. Soosay, B. Fahimnia, and J. Sarkis. 2014. "Framing Sustainability Performance of Supply Chains with Multidimensional Indicators." *Supply Chain Management: An International Journal* 19: 242–257.
Vlachos, I. P. 2016. "Reverse Logistics Capabilities and Firm Performance: The Mediating Role of Business Strategy." *International Journal of Logistics Research and Applications* 19: 424–442.
Vlajic, J. V., S. W. M. van Lokven, R. Haijema, and J. G. A. J. van der Vorst. 2013. "Using Vulnerability Performance Indicators to Attain Food Supply Chain Robustness." *Production Planning and Control* 24: 785–799.
Wang, M., F. Jie, and A. Abareshi. 2015. "Business Logistics Performance Measurement in Third-party Logistics: An Empirical Analysis of Australian Courier Firms." *International Journal of Business and Information* 10: 323–336.
Wang, Y., A. Potter, R. Mason, and M. Naim. 2008. "Aligning Transport Performance Measures with Customised Retail Logistics: A Structured Method and Its Application." *International Journal of Logistics Research and Applications* 11: 457–473.
Webster, E., and P. H. Jensen. 2006. "Investment in Intangible Capital: An Enterprise Perspective." *The Economic Record* 82: 82–96.
Wibowo, M. A., and M. N. Sholeh. 2015. "The Analysis of Supply Chain Performance Measurement at Construction Project." *Procedia Engineering* 125: 25–31.
Wiig, K. M. 1997. "Integrating Intellectual Capital and Knowledge Management." *Long Range Planning* 30: 399–405.
Wong, D. W. C., K. L. Choy, H. K. H. Chow, and C. Lin. 2014. "Assessing a Cross-border Logistics Policy Using a Performance Measurement System Framework: The Case of Hong Kong and the Pearl River Delta Region." *International Journal of Systems Science* 45: 1306–1320.

Wong, W. P., and K. Y. Wong. 2008. "A Review on Benchmarking of Supply Chain Performance Measures." *Benchmarking: An International Journal* 15: 25–51.

Wu, Y. C. J. 2006. "Assessment of Technological Innovations in Patenting for 3rd Party Logistics Providers." *Journal of Enterprise Information Management* 19: 504–524.

Wu, Y. C. J., and Y. H. Chou. 2007. "A New Look at Logistics Business Performance: Intellectual Capital Perspective." *The International Journal of Logistics Management* 18: 41–63.

Wu, Y. C. J., and Y. H. Lin. 2005. "Performance Assessment in Logistics: Patents as an Input Variable." *Journal of Technology Management* 10: 57–86.

Yang, J. 2009. "The Determinants of Supply Chain Alliance Performance: An Empirical Study." *International Journal of Production Research* 47: 1055–1069.

Yang, J. 2012. "A Structural Model of Supply Chain Performance in an Emerging Economy." *International Journal of Production Research* 50: 3895–3903.

Yang, C. C., P. B. Marlow, and C. S. Lu. 2009. "Assessing Resources, Logistics Service Capabilities, Innovation Capabilities and the Performance of Container Shipping Services in Taiwan." *International Journal of Production Economics* 122: 4–20.

Yogi, K. S. 2015. "Performance Evaluation of Reverse Logistics: A Case of LPG Agency." *Cogent Business and Management* 2: 1–17.

Zailani, S., M. R. Shaharudin, K. Razmi, and M. Iranmanesh. 2015. "Influential Factors and Performance of Logistics Outsourcing Practices: An Evidence of Malaysian Companies." *Review of Managerial Science* 11: 1–42.

Zaman, K. A. U., and A. M. M. N. Ahsan. 2014. "Lean Supply Chain Performance Measurement." *International Journal of Productivity and Performance Management* 63: 588–612.